SCIENCE TEACHER'S WORLD

Teacher's edition of Science World • May 5, 1959

At your demonstration table

By Morris Meister

The demonstration table is the distinguishing feature of the science room. The activities which center around it probably account for a high percentage of what the student learns. When it functions properly, it is the source of most of the stimuli to worthwhile activity, provides vital experiences, and creates the type of interest which calls forth real effort.

How demonstrations can function

1. A well-organized set of demonstrations is the best lesson plan.

When ideas or topics are presented to a class for the first time, the teacher is interested in directing the thinking of his students so that at the end of the period definite concepts are established. Concepts are built up from experiences, and these experiences must follow one another in a more or less definite order if the teacher's aims are to be realized. The art of the teacher lies in the skill with which he arranges his demonstration experiments.

2. Demonstrations can be used to arouse interest and challenge curiosity.

Stand a radiometer in the path of the sun's rays. Remove it to the shade. Bring an electric lamp or lighted match near it. (There are many such devices and experiments which may be presented in pantomime.) The students observe and wonder about it. There is no need to answer questions immediately. Let them think about it, perhaps write their thoughts in their notebooks. Later, the matter is discussed and the phenomenon explained. Such procedure is an excellent method of introducing a topic.

3. Demonstrations can be used to raise problems.

Several sterile Petri dishes are exposed to the air in various parts of the room. When given the proper conditions, each dish soon develops decided evidence of growing organisms. These organisms are associated with the decay of foodstuffs. How can we prevent the spoiling of different foods by exposure to the air? This problem arises naturally from the demonstration, as do many others. The stimulus to thinking and to purposeful activity has come from the demonstration.

4. Demonstrations can be used to illustrate principles.

The air is a real substance and exerts a pressure on all surfaces against which it rests. To develop a permanent appreciation of these facts, numerous experiences and illustrations are desirable. The teacher therefore boils a little water in a tin can so as to expel the air, stops up the opening and allows the can to cool. Before long the can collapses as if some invisible giant has crushed it. The demonstration has served to illustrate the principle of air pressure.

5. Demonstrations can be used to test the knowledge of the class.

Instead of, say, a written test, perform a series of experiments in pantomime. After each demonstration have the class write out the explanation of the phenomenon observed.

6. Demonstrations can be used to review topics.

The essential experiences which the teacher utilizes in developing ideas and concepts can be repeated in modified ways. The ability to generalize is a valuable one and teachers must provide opportunity for its exercise.

7. Certain "key" demonstrations can serve as a basis for homework.

Every time we demonstrate a fire-extinguisher, we assign the project of making a "homemade fire-extinguisher." In general, it may be said that the teacher's demonstrations stimulate the student to individual experimentation. This outgrowth from the teacher's activity is among the most valuable features of demonstration work and must be encouraged.

8. When we offer a demonstration to answer a question raised by a student we provide a highly educative experience.

It is a very effective answer and indicates a method of discovery that is the gist of the scientific method.

"How high would the mercury column be if a four-foot tube instead of a three-foot tube were used in the barometer experiment?" "Let's try it and find out," says the teacher.

Some points in technique

1. Try out your experiments in advance; but develop in your class the attitude that real scientists never expect their apparatus to work perfectly all the time. When something goes wrong, challenge the class to tell you why.

2. As far as possible, have only one experiment or piece of apparatus on your table at one time. It minimizes distractions and helps to focus attention.

3. Have a large white cardboard handy to serve as a background. This helps the class to see more clearly.

4. Whenever possible, assemble the parts of an apparatus before your class. In some cases, especially where essential parts are hidden, take the apparatus apart.

5. Letting a student repeat an experiment before the class is sometimes very worth while.

6. Use student assistants before, during, and after demonstration experiments.

7. Do not be satisfied with one experiment to illustrate an idea or principle. The more experiments you can

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The next issue of SW, May 19, is the last of this semester. If you haven't already done it, may we remind you to use the tentative order card in this issue? It does not obligate you in any way, but you will greatly help us by estimating your fall needs now.

gather to develop a law of science, the more truly will your class grasp what you are trying to teach.

8. Especially in the beginning of the term's work should your experiments and apparatus be simple and appear simple. The complex-looking apparatus will, after the initial stimulus, destroy real interest.

9. Provide ample opportunity for everyone to examine and observe at close range before calling for reactions.

10. Where the apparatus or experiment permits, encourage your class to suggest alterations and new conditions.

11. Encourage your class to think up original experiments to illustrate principles developed in class.

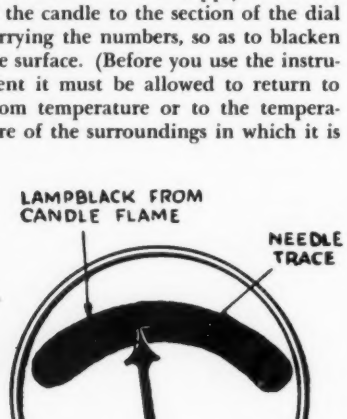
12. Some form of note-taking on the part of students is desirable. In our own experience we have adopted a simple form, which calls for a statement of purpose, a description of what is done or what happens, and a statement of conclusions. Students are encouraged to supplement this with as much discussion and development as they wish, but they must keep this part of their notes distinct from the threefold requirement outlined above.

How to do it

A simple homemade minimum and maximum thermometer

At some time or other in a science teacher's classroom experience, a maximum and minimum thermometer is a necessity. The commercial forms are expensive, fragile, and difficult to adjust. It is possible to make a simple maximum and minimum thermometer in a few minutes. All that is necessary is a five-and-ten-cent-store metallic thermometer of the type equipped with a dial. These are also available in hardware stores. The other necessary part is a wax candle.

To make the instrument, first remove the glass or celluloid face of the instrument. This may be discarded, as it will not be needed. Apply the flame of the candle to the section of the dial carrying the numbers, so as to blacken the surface. (Before you use the instrument it must be allowed to return to room temperature or to the temperature of the surroundings in which it is to be used.) Now bend the tip of the needle so that it touches the surface of the dial. As the temperature increases or decreases, the needle will trace a track through the lampblack deposited by the candle. By removing the lampblack from each end of the trace made by the needle, the maximum and minimum temperatures are read. This makes an excellent instrument for homemade weather stations. Another advantage of the instrument is its compactness as compared to the standard maximum and minimum thermometer.



Gathering quantitative data

Gathering quantitative data is a desirable kind of activity in science learning. Here are two examples — one in the form of a demonstration lesson and the other in a laboratory lesson — of how it can be done.

A. Demonstration lesson— studies in cooling by evaporation

Demonstrate the cooling effect of evaporation by using two thermometers, each of which shows room temperature. One of these is to serve as a control. Wet the bulb of the other thermometer with water. Have a student observe that the level of mercury in this thermometer falls and then rises again.

QUESTION: How far did the level fall? What caused the level to fall? Why did it rise again?

Repeat, but *this* time *re*-wet the bulb when the mercury level is at its lowest point. Also repeat, using alcohol in place of water.

QUESTION: How *low* can you make the temperature fall by repeated wetting in water? In alcohol?

This question can serve as the basis of an interesting laboratory lesson. Or it can be farmed out to an individual student to investigate at home.

B. Laboratory lesson— investigations of friction

PROBLEM: to compare the forces necessary to start an object moving along a surface. The variables are the weight of the object, the area of contact with the surface, and the degree of roughness of the surface.

(Note: In many general science classes, apparatus — for example, a sufficient number of spring balances — for individual laboratory work is not available. Notice how this obstacle is overcome by improvisation.)

METHOD: provide each student (or pair of students) with a ruler, a block of wood (one end of which contains a screw eye or cup hook), a rubber band, and two pieces of sandpaper (one "fine" and one "coarse").

The student attaches the rubber band to the screw eye or cup hook. He places the ruler so that the extended, but unstretched, rubber band is at zero inches. He stretches the rubber band and notes at what length the object begins to move. He records the "inches of stretch" to represent the force.

The method can be applied to (1) a block of wood with stones on it; (2) a block sliding over a pane of glass; (3) a block sliding over the bare surface of a desk; (4) a block sliding over "fine" sandpaper and over "coarse" sandpaper; and (5) blocks that have the same weight, but have different areas of contact with the surface. When the same rubber band is used and when one variable is checked at a time, the data gathered are comparable and subject to significant interpretation.

MEMO

To: Science teachers

Subject: Ways to use this issue of SCIENCE WORLD in the classroom

The Comet comeback

GENERAL SCIENCE TOPICS: jet flight, air pressure
VOCATIONAL GUIDANCE TOPIC: aeronautical engineering
SCIENCE CLUB TOPIC: testing jet aircraft

"Roaring across the world's air oceans at 35,000 feet, America's jet-transport pilots are inaugurating a new era in super-fast, super-safe aviation, thanks to the fabulous research and testing methods," says the author. He describes in detail and with clarity the research and testing methods that have been developed since the ill-fated de Havilland Comet G-ALYP exploded in mid-air back in 1954. The reader will come away from this article with an enhanced appreciation of the "jet age" in which he lives.

Report and discussion suggestions

1. Describe the salvage operations undertaken to recover the de Havilland Comets that exploded in mid-air in 1954.
2. Why are pressurization tests performed underwater?
3. Describe the method and importance of each of the following tests: icing test, bird test, wing test, vibration test, dust and debris test, skin test.

Originality in projects

BIOLOGY TOPICS: reproduction and others (see below)
CHEMISTRY TOPICS: electromotive series, corrosion

The two student projects described so clearly by Dr. Benjamin suggest any number of related projects, class demonstrations, and areas of fruitful laboratory work. Linda Wood's experiment with brine shrimp serves to remind us of the many uses in biology teaching that can be made of *Artemia, Daphnia, Cyclops, Gammarus, Eubranchipus,* and other small crustacea that can readily be cultured. Not only can they be used in teaching the topic of reproduction, but they are good subjects for demonstrating tropisms, digestion (peristalsis), respiration, nutrition, and even effects of hormones. (For details, see Morholt, Brandwein, and Joseph, *Sourcebook for the Biological Sciences.*)

The chemistry teacher will find in Alexandra Jagiello's project a spectacular and novel way to demonstrate electrolytic action on metals.

The projects of both these girls, as described, can serve as models for the teacher to hold up to the class. Each of them involved real scientific investigation of a problem, experimental design, collection of data, determining the meaning and significance of the data, and a neat, orderly, and clear report.

The mysterious motor of life

BIOLOGY AND GENERAL SCIENCE TOPIC: photosynthesis
EARTH SCIENCE TOPIC: fossil fuels

The master science teacher teaches not only what is known but goes on to indicate as clearly as possible what is *unknown.* Mr. Harvey's article affords the biology teacher an opportunity to call attention to a number of "unknowns" about photosynthesis. At the same time, the article describes the strategy of a twelve-man team — including biochemists, biophysicists, phys-

iologists, and electron microscopists — in their concerted attempt to arrive at an understanding of just how photosynthesis takes place. Should a break-through occur, it will be the most revolutionary scientific accomplishment since the release of nuclear energy. Some spectacular possibilities are described in this article.

Questions for class reports

1. Describe two "mysteries" regarding photosynthesis that are being investigated.
2. How have chloroplasts in solution been made to act "natural"?
3. How is carbon-14 being used to discover intermediate compounds involved in photosynthesis?
4. Describe the unexpected relationship between light intensity and photosynthesis.

The subtle storm

PHYSICS AND GENERAL SCIENCE TOPICS: the ionosphere, short-wave radio transmission, sunspots, solar flares and auroras
EARTH SCIENCE TOPIC: weather cycles
BIOLOGY TOPIC: population cycles

This is Part 2 of an article that began in the April 21 issue of SCIENCE WORLD and that will end in the May 19 issue. A general description of the article appears in "Memo" for April 21. The content-coverage of Part 2 can be inferred from the questions below.

Review and discussion questions

1. At what altitude does the region of ionized air that blankets the earth begin, and how thick is it?
2. How does the ionosphere serve long-range radio broadcasting?
3. What is the effect of a magnetic storm on (a) long-range radio broadcasting? (b) circuit breakers? (c) telegraphy?
4. How frequently do magnetic storms occur?
5. How was the great magnetic storm of 1958 predicted?
6. What is believed to be the cause of a magnetic storm?
7. Why are auroral displays most brilliant near the earth's North and South Poles?
8. What biological, meteorological, and even social phenomena seem to be geared to the sunspot cycle?
9. What events preceded and accompanied the great magnetic storm of 1958?

Darwin and the origin of species

BIOLOGY UNIT: change in plant and animal species

In many high school biology courses, the unit on change in plant and animal species comes near the end of the school year. At the present time, therefore, Miss Wyler's historical and biographical account of Charles Darwin and his theory is a made-to-order "chapter" for biology classes. In her story, the lives and work of the Darwins — grandfather and grandson — and those of Lyell, Wallace, and Huxley are neatly tied together. The author links Charles Darwin, Galileo, and Newton as a trio that revolutionized man's thinking about the world around him and about man's place in the universe.

The article is especially timely for another reason: this year marks the centennial of the publication of *Origin of Species*, and the event will be celebrated in scientific and cultural circles throughout the world. The article can serve as background for stimulating interest in many items that will appear in newspapers, magazines, and in museum and television programs.

The talented student might be stimulated to look into Lyell's *Principles of Geology* and to read Darwin's *Voyage of the Beagle*.

Discussion questions

1. What ideas of Lyell's influenced Darwin's thinking about the world of living things?
2. What observations during Darwin's voyage on the *Beagle* influenced his thinking?
3. How did a knowledge of plant and animal breeding contribute to Darwin's theory?
4. In what contrasting ways were Darwin's and Wallace's reports written?
5. How did it come about that Darwin's and Wallace's reports were read at the same meeting of the Linnean Society?

Gold key requests

If you are planning to award our gold-filled key to one of your students, now is the time to let us know. Keys will be given to teachers who have ordered ten or more classroom subscriptions to SCIENCE WORLD. Please note that the keys and their accompanying certificates are available ON REQUEST only. They should be requested according to this scale:

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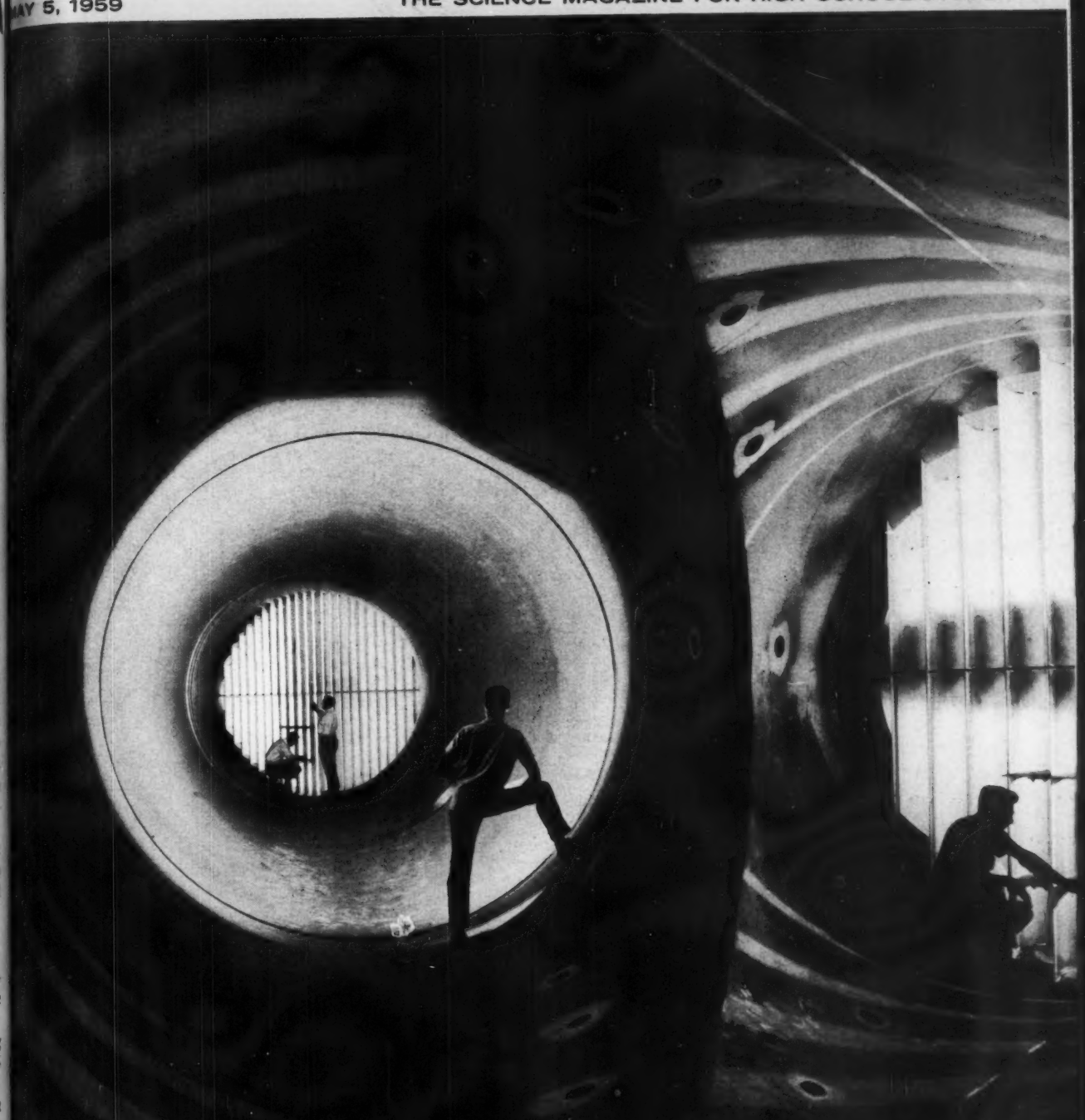
MAY 5, 1959 THE SCIENCE MAGAZINE FOR HIGH SCHOOL STUDENTS



What is this?

(For answer, see page 3)

The cars are safer... the roads are safer...

THE REST IS UP TO YOU!

You're on top of the world on graduation evening. And no wonder! Who wouldn't be excited at this milestone in his life? But remember—keep this night a happy memory by driving safely. Your parents have shown their confidence in you by permitting you to drive tonight. Your best girl's parents have placed their trust in you, too. Don't let them down.

A lot of people have an interest in your safety while driving. Automotive manufacturers have designed safer cars with more powerful brakes, better steering, headlights and tires, and more glass area for wider visibility. Traffic officials have built expressways with interchanges, underpasses and overpasses, put up road markers and traffic signs that are easier to see and understand.

The rest of the responsibility is yours. You know what makes a safe driver—if you didn't you wouldn't have the privilege of driving.

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GENERAL MOTORS A CAR IS A BIG RESPONSIBILITY—SO HANDLE WITH CARE!

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Coming in *SW*, May 19

What fuel, found in sea water, may one day give us unlimited power? What is the major problem faced by scientists working on thermonuclear power?

How can the chirps of a cricket be used as an indicator of temperature?

How have scientists managed to "tame" live polio viruses for use in vaccine?

During World War II, U.S. and British researchers invented a self-repairing aircraft carrier. What material was used?

For answers, see next issue of *SW*.

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Cover photo from NASA

Cover story

The strangely patterned photo on *SW*'s front cover this issue shows the juncture of air passages leading to the two test sections of a supersonic wind tunnel at NASA's Langley Aeronautical Laboratory. Studies are made in the tunnel at velocities ranging from 1.5 to 5 times the speed of sound — approximately 1,100 to 3,800 mph at sea level. Each test section operates in a different speed range, but both are four feet wide, four feet high, and seven feet long. The guide vanes shown in the air passages help turn the air smoothly as it returns from the two test areas. Behind the guide vanes on the right is a large valve for cutting off the inoperative test section while research is being conducted in the other. (For more on jets and testing, see pages 25-28.)

Safety first

Driving to a baseball game? To the spring prom? Wherever you're going, obey the rules of good driving and make sure you get there safely.

By Rose Wyler

DARWIN and 'Origin of Species'

In 1859, just 100 years ago,

a shy scientist published an explosive book

that revolutionized thinking

in the natural and social sciences

■ A bombshell burst upon the world of ideas one hundred years ago, when Charles Darwin (1809-82) of England published his book *Origin of Species*. Presenting the first systematic proof of evolution and a theory to explain the process, the book set off a revolution in the natural and social sciences. Suddenly, millions of years were added to earth history; time became a new dimension in thinking; and man's place in nature appeared in new perspective.

Before Darwin's work was known, many people thought that the earth and life had come into being in the year 4,000 B.C. The generally accepted idea was that each plant and animal species was of separate origin and that its form was permanent. Man had no relationship to any other organism.

A few scientists believed that plant and animal types had gradually changed through the ages and that old species evolved into new species. But these men had no satisfactory theory to explain how such evolution came about. Nor could they offer clear-cut evidence that organisms had been modified, for the study of fossils was still in its early stages.

One of these evolutionists was Darwin's own grandfather — Erasmus Darwin. In his youth, Charles was fascinated by the ideas his grandfather had put forth but tended to believe in the accepted ideas of his day.

The son of a rich and prominent family, Charles attended an excellent school. His main interests were collecting shells, coins, and minerals; hunting insects and birds' nests; and fishing. Since his grandfather and father were both physicians, at 16 Charles was shipped off to study medicine at Edinburgh University. But dissections, operations, and the sight of physical suffering were more than he could stand, and after two years he left.

Entering Cambridge University, Charles found most of his courses, including several in science, dull, although he enjoyed field work in geology and botany, and he read extensively in natural history.

Shortly after graduation, Dr. Henslow, Darwin's botany professor helped him obtain an appointment as the naturalist on board the *Beagle*, a Royal Navy sailing vessel about to leave for a five-year expedition around the world, exploring and mapping coastlines. Later Darwin was to write: "The voyage of the *Beagle* has been by far the most important event in my life, and has determined my whole career."

Dr. Henslow suggested that, before sailing, Darwin should look into *Principles of Geology*, a new book by Charles Lyell — adding that it shouldn't be taken too seriously. The book's main thesis was that earth forces now at work have been in continuous operation through the ages; therefore, Lyell argued, the present is the key to the past. Darwin read the book carefully and

became converted to Lyell's teachings.

From the start of the long trip across the Atlantic, the 23-year-old naturalist eagerly awaited the sight of land and the opportunity to test Lyell's methods. While stopping at St. Jago in the Cape Verde Islands, he studied the island's lava-capped coral rock. He found that after the island had been uplifted, it had sunk below sea level, only to be uplifted again. Thrilled with his discovery, he decided he would write on the geology of the various countries he visited. This decision led to three works on geology.

Each day, Darwin carefully recorded his observations, experiences, and thoughts. This journal became his famous and fascinating *Voyage of the Beagle*, first published in 1839. Reading the book today, we see how, discovering the world, Darwin discovers himself, and we follow his development into a mature scientist probing into life's deepest mysteries.

At the beginning of the voyage, Darwin's ideas on evolution were vague. But he began to question the permanence of species soon after he arrived in South America. In Brazil, he discovered the fossil remains of a gigantic ground sloth: in the Argentine pampas, he stumbled across a "graveyard" of extinct armadillos. Studying the bones he had unearthed, he found they resembled the bones of living sloths and armadillos. There was no doubt in his mind that the living species were related to the extinct ones. But how had this relationship come about, and why had the fossil types died out?

Traveling southward along the South American continent, Darwin found that animals fitted for life in the tropics were gradually displaced by similar species adapted to increasingly colder climates. He could not believe that each of these had arisen separately in the very small area it occupied.

Crossing the Andes, he noted something else. In some places, climates and soils on both sides were similar, yet the animals of the east slopes were different from the same species on the west. Why?

The same problem came up in the Galapagos Islands, off the coast of Ecuador. A local official told Darwin he could tell which island he was on just by looking at the giant tortoises, for each island had its own distinct species.

"It was evident that such facts as these, as well as many others," wrote Darwin, "could only be explained on the supposition that the species gradually became modified, and the subject haunted me."

The year after his return to England, Darwin started a notebook for his ideas on the origin of species. But twenty-two years passed before he published on the subject.

Adventurous Darwin became a settled country gentleman. He had married his cousin, Emma Wedgwood, and they were raising a family in a comfortable home in Downe, near London.

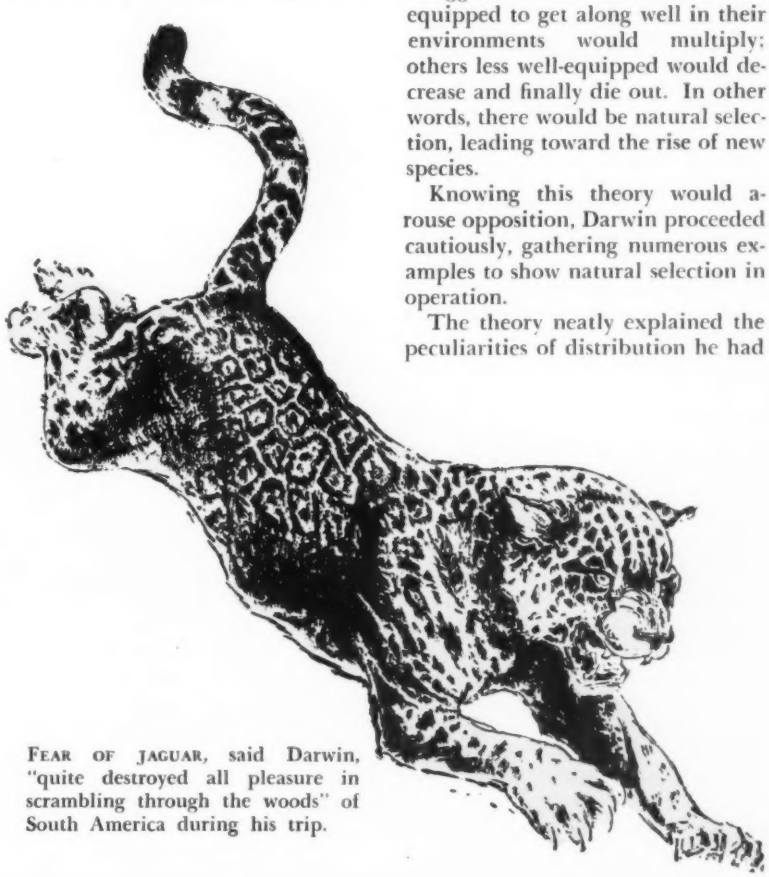
Illness made serious inroads into his working time. Whether his symptoms were physical or psychological in origin has never been determined. In any case, they served as an excuse from public appearances. Darwin, with all his intellectual daring, was too timid to face an audience.

In planning his work on the origin of species, Darwin decided to take a cue from Lyell; he would study the present to unravel the past. Nurserymen and stock breeders were modifying domesticated plants and animals, and he inquired into their methods. He found that for breeding they carefully selected individuals with the most useful characteristics and that gradually they developed more useful lines of plants and animals. Nature, too, must select, Darwin decided, but he wondered why certain variations were favored.

A clue came from an essay on population by T. R. Malthus. The author believed the human race increases far more rapidly than the food supply, and consequently there is a struggle for existence in which only the strongest survive. Suddenly, it struck Darwin that plants and animals also compete for food and other necessities of life. In their struggle for existence, variations equipped to get along well in their environments would multiply; others less well-equipped would decrease and finally die out. In other words, there would be natural selection, leading toward the rise of new species.

Knowing this theory would arouse opposition, Darwin proceeded cautiously, gathering numerous examples to show natural selection in operation.

The theory neatly explained the peculiarities of distribution he had



FEAR OF JAGUAR, said Darwin, "quite destroyed all pleasure in scrambling through the woods" of South America during his trip.

encountered in South America. Darwin reasoned that similar species were descended from a common ancestral species. In spreading into different regions, the descendants that multiplied and survived were those best adapted to the new environments. And so, in the course of many generations, a number of specialized lines appeared. Each of these eventually varied so much from the ancestral prototype that it became a distinct species.

As Darwin continued his studies, he began to think that all life probably arose from a few ancestral types. To trace relationships, he used a tree diagram. The trunk and main branches represented the common ancestral types, and the smaller branches and twigs represented descendants which had differentiated from them. "From the first growth of the tree," he wrote, "many a limb and branch has decayed and dropped off; and these fallen branches of various sizes may represent those whole orders, families and genera which have now no living representatives, and which are known to us only in a fossil state."

The human species, it seemed, like all others must have a place in the tree of life. Darwin thought it illogical to suppose that only man arose separately from all other creatures. Through a study of comparative anatomy, he became convinced that man's descent could be traced to lower animals. He felt sure that fossil links indicating this would be discovered — and they have been.

Darwin's work proceeded so slowly that, by 1842, he had only a 35-page outline of his theory. Two years later, he developed this into a 230-page manuscript and sent a copy to Professor Lyell. Later, he showed a copy to Professor Hooker, a well-known botanist. Both men were so impressed with the paper, they urged publication. But Darwin decided he needed more facts to support his theory and planned a lengthy, comprehensive work. The years rolled by and, at the age of 49, Darwin had finished only half of his big work on the origin of species.

Meanwhile, another English naturalist, Alfred Russel Wallace (1823-1913) had been traveling to distant corners of the world, collecting for museums. In South America, Wallace began to study the distribution of species. Visiting the Malay Archipelago, he noticed neighboring islands were inhabited by similar yet different species. Wallace, too, read Malthus, and with a flash of insight reached the same conclusions Darwin had reached twenty years earlier. Hastily, Wallace — who knew nothing of Darwin's projected work — wrote out his theory and mailed a copy to the famous naturalist Charles Darwin, asking him to forward it to Lyell for comment.

On June 18, 1858, Wallace's paper arrived at Downe. Darwin's eye immediately fell on its title: "On the Tendency of Varieties to Depart Indefinitely from the Original Type." He was stunned. The manuscript read like an abstract of his own theory. Wallace had even used terms indentical with his own!

Should he have the paper published? Wallace had not requested this, but he felt obligated to see it was printed. Then what about his own work? Despondently, he forwarded the paper to Lyell and asked him for advice. Lyell, as well as Hooker, felt Darwin should release an abstract of the 1844 manuscript simultaneously with Wallace's paper. The two men quickly arranged for publication in the *Journal of the Linnean Society*, and on July 1, 1858, they read both works to the Society. Darwin, however, was too ill to attend the meeting.

The reading caused little comment. It was as though the fuse of a time bomb had been lighted without attracting any attention. The detonation came in November, 1859, when Darwin finally published *On the Origin of Species by Means of Natural Selection*. Within thirteen months, Darwin had cut his lengthy manuscript and completed a short book which was an immediate success. Evolution became the most discussed issue of the day, and a storm of opposition built up. Among the opponents were many conservative Victorians who were shocked by the implication that their "ancestors" were lower animals. Assuming Olympian dignity, Darwin tried to remain "above the battle" and permit the facts to speak for themselves. But other scientists thought this was not enough and rallied to his defense.

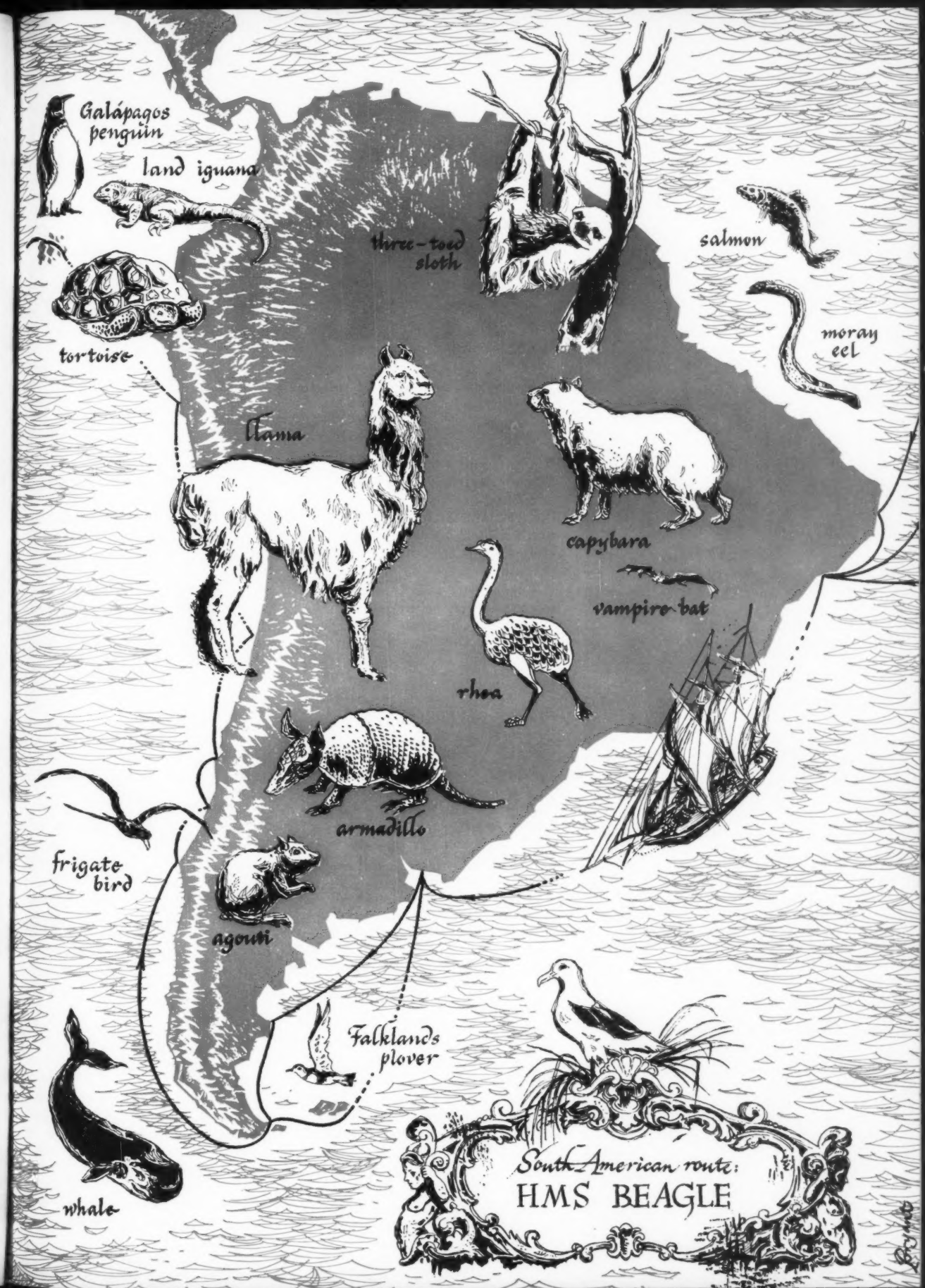
Most eloquent was the fiery biologist Thomas Huxley, who became known as "Darwin's bulldog." At every opportunity, Huxley defended not only Darwin's right to reject conventional views, but the right of all scientists to inquire freely into nature's laws.

Darwin, though now world-famous, continued to work quietly at Downe. He prepared a book called *The Descent of Man*, as well as a number of limited studies on plants and animals. By the time of his death in 1882, much of the furor created by *Origin of Species* had died down. Gradually, the doctrine of evolution became accepted, and biologists began to build on Darwin's work.

The building goes on today. The theory of natural selection has been modified. Competition within a species is recognized as a factor, but it is also recognized that in many cases co-operation has had survival value. Certainly, in the case of social animals and man, co-operation has played a major role.

One great problem in evolutionary theory could not be solved in Darwin's time. No one could explain how variations arise. The study of heredity and of mutations has helped close this gap. But actually the problem of the origin of species is still not completely solved, for the cause of mutations is not fully understood.

Such gaps in Darwin's work do not detract from his enormous contributions. Modern science rests on the shoulders of giants, and Darwin was one of the giants. He stands with Galileo and Newton. They showed that the earth is not the center of the universe, but that it is a small planet in the vastness of space. Darwin showed man in his true relationship to other forms of life. He made it impossible to believe that nature is static, convincing the world "that, whilst this planet has gone cycling on according to the fixed law of gravity, from so simple a beginning endless forms most beautiful and most wonderful have been, and are being evolved."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tortoise
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salmon
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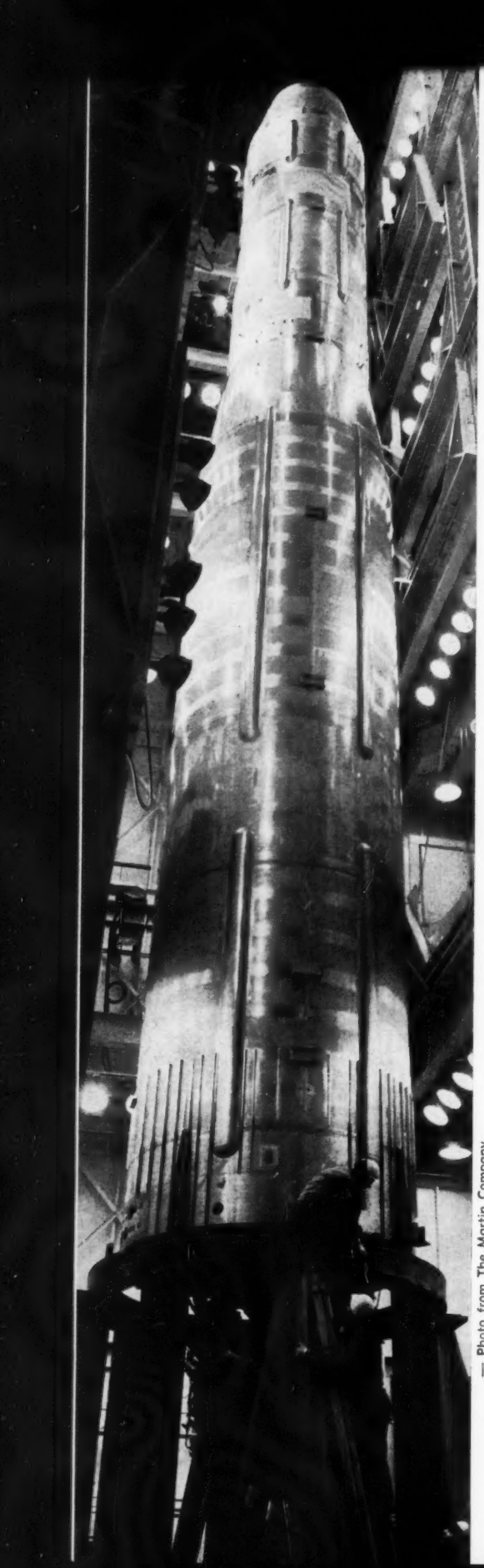


Photo from The Martin Company

By Jules Bergman

The great rocketry race

Here's a rundown on where the U.S. and Russia stand today in space exploration and missile development

■ A year and a half ago the Soviet Union electrified the world by launching the first man-made satellite. It immediately became clear that Russia had forged ahead of the United States in rocket and missile development.

Since then, the U.S. has also scored rocketry triumphs. But no one suggests that we have as yet caught up with the Russians. In fact, almost everyone agrees it will take a major effort to do so.

Is the U.S. making the necessary effort? Around this question a great debate is raging. Some Congressmen and scientists say the U.S. is skimping dangerously on its rocketry dollars. But the Eisenhower Administration says we are doing all that is necessary and warns that the real danger lies in putting too much of our national output into rockets and missiles.

At this point it is impossible to predict the outcome of the rocketry race. But it *is* possible to assess where the two countries stand today.

How did Russia get ahead?

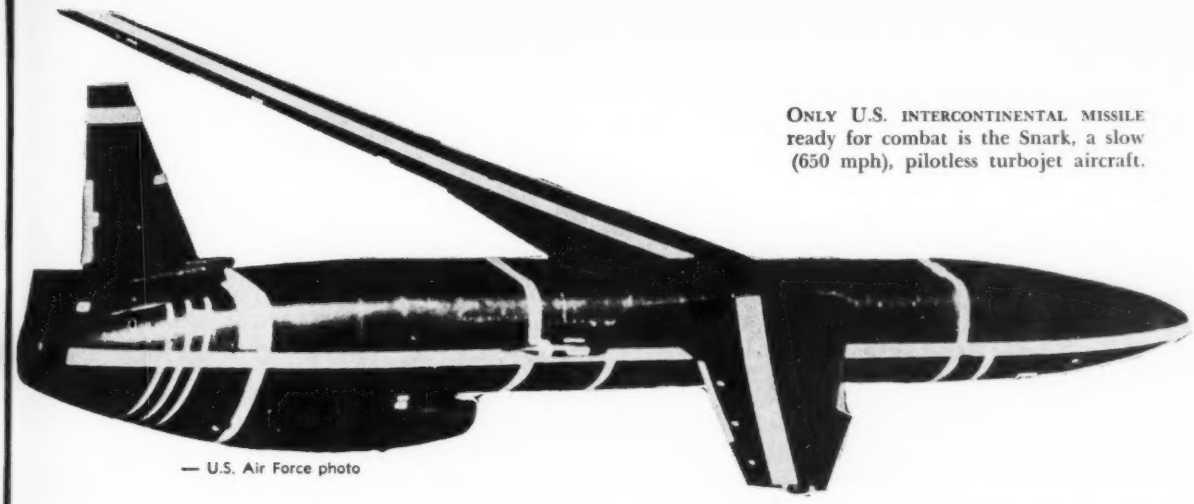
At the end of World War II, the U.S. and Russia each got part of the gold mine of German rockets, scientists, and production equipment at Peenemünde. The Russians — with Stalin's blessing — immediately embarked on a crash research and production program. They picked the brains of the German scientists, then sent them home. They systematically exploited German power plants and guidance and control equipment. The thrust of the German V-2 rocket was increased from 55,000 to 77,000 pounds, extending its range from 200 to 700 miles. The Russians then developed a rocket engine with a thrust of 265,000 pounds and talked of an engine with 551,000 pounds of thrust. Their first intercontinental ballistic missile (ICBM) almost certainly had its beginnings in Peenemünde.

Meanwhile, U.S. missilemen were hampered by small peacetime budgets. At first they could do little more than test and refine German V-2's. Our Atlas ICBM program had its beginnings in 1947, but was promptly shelved for lack of funds. Serious work on the Atlas did not go forward until after the 1952 nuclear tests. These confirmed that a hydrogen bomb could be made small enough to be delivered by a missile.

Not all missile work was neglected during those years. The Army, Air Force, and Navy were developing smaller missiles: air-to-air Sidewinders and Falcons; anti-aircraft Nikes, Terriers, and Bomarcs; and artillery missiles such as Corporal and Sergeant.

Work on the Thor and Jupiter intermediate-range ballistic missiles (IRBM's) was also started. These are now becoming operational (combat-ready) and can reach So-

← AIR FORCE'S TITAN ICBM is put through ground tests. A two-stage missile, its range will be about 6,500 miles.



ONLY U.S. INTERCONTINENTAL MISSILE ready for combat is the Snark, a slow (650 mph), pilotless turbojet aircraft.

— U.S. Air Force photo

viet soil from our European bases. But the only intercontinental missile we can claim operational status for is the Snark — a subsonic (650 mph) air-breathing pilotless bomber. The first Atlas ICBM's will be ready by summer.

Are Russian rockets more powerful than ours?

Moscow has never disclosed the power ratings of its missiles. But our scientists, calculating what it took to launch the heavy Soviet satellites, figure Russian ICBM's have a thrust of 500,000 to 800,000 pounds. Our Atlas and Titan ICBM's have a top power-rating of 365,000 pounds. They have power to spare for their military job, but lack the punch to lift really huge payloads into space for exploration purposes.

Vastly more powerful rockets have been ordered by the Pentagon and by the National Aeronautics and Space Administration. A cluster of rockets and a single rocket engine, each with 1.5 million pounds of thrust, are being developed. Either of these will be capable of landing manned vehicles on the moon and sending large payloads to Mars and Venus. And there is talk of combining four or more of the giant 1.5-million-pound-thrust rocket engines into a huge cluster to carry manned craft to more distant planets.

Where is Russia ahead?

By turning out huge ICBM's the Soviet Union was able to get a substantial lead on us not only in long-range military missiles but in space exploration. Soviet satellites have carried payloads tremendously heavier than any of ours have. And rocket power enabled the Russians to put the first animal, a dog, into orbit.

It will be several years before our big new rockets are ready, enabling us to equal Soviet achievements. During that time the Russians will be able to send bigger payloads a greater distance into space. And Moscow will be striving to develop even more powerful rockets. The time advantage the Russians have gained will be difficult for us to overcome. Wernher von Braun, chief of development of the Army's Missile Agency, estimates it would take us eighteen to twenty-four months to catch up if Russia stood still. Other space experts are more optimistic. But there is little doubt that Russia has acquired an over-all lead in the race to space.

Where is the U.S. ahead?

There is every reason to think the U.S. is ahead in the area of solid-fuel missiles, though no one knows this for certain. Our underwater-launched Polaris missile and the projected Minuteman ICBM may eventually give us an edge over Moscow in missile superiority. For solid-fuel missiles will be easier and quicker to launch.

Our scientists also feel U.S. instrumentation is superior to that of Russia. Because of the limited power of our rockets, lightweight, "sophisticated" instruments had to be developed. These instruments, as used in our rockets and satellites, may tell as much and tell it better than the much heavier Soviet instruments.

Another area in which our experts feel we may lead Russia is space medicine. This area is just as vital in the race for space as are the rockets that carry man out of this world. While Soviet experimentation in space medicine is directed along much the same lines as ours, U.S. efforts to guarantee man's survival in space seem further advanced. This does not mean that the U.S. will necessarily achieve manned space flight as soon as the Russians do. It does mean that our first astronauts will undergo no greater risk than test pilots of high speed jets. It's unlikely that the Russians will be as concerned with human safety.

Who will put the first man into orbit?

Russia, which has been talking about manned space stations for some time, looks certain to beat us on this score. It's possible, though, that our X-15 rocket plane may orbit the earth once or twice this year and beat Russia to the punch. Later plans include the possibility of putting the X-15 into larger orbits for longer periods by rigging it to an Atlas or Titan missile.

The National Aeronautics and Space Administration, meanwhile, is going ahead with Project Mercury — its plan to launch a manned

space capsule into orbit. But this goal is at least two years away. The process of selecting the seven test pilots from whom our first astronaut will finally be chosen was recently completed. And NASA has already ordered the space capsule. But exhaustive tests must be made before any American's life will be risked in space flight.

Who will build the first moon base?

Soviet scientists have already announced that they are at work on plans for a manned lunar base. It would be used as an observatory to look out into space and as a way station for manned interplanetary rockets.

The Russians submit no timetable on a lunar base, nor does the United States. NASA wants no confining schedule — it wants progress in research to dictate our timing. U.S. space experts, such as Krafft Ehricke of Convair-Astronautics, feel a base can be established on the moon in five to ten years, depending on how much priority the project is given.

The foreboding with which American scientists regard Soviet ambitions toward the moon is best exemplified by the testimony of a famed nuclear physicist, Dr. Edward Teller. When asked by a Congressional group what he expected to find on the moon, he replied, "Russians."

Who will build the first nuclear rocket?

Here, again, Russia seems to be leading. Moscow's plans for nuclear rockets and aircraft are no secret. And some observers claim to have seen a huge nuclear-powered bomber being tested high over Moscow. With an unlimited range, nuclear-powered craft could be invaluable both for military use on earth and for space exploration.

Atom-powered aircraft and rockets have long been high-priority Soviet projects. Three years ago, Soviet journals described several nuclear engines and showed a sketch of a six-stage cosmic rocket. Its first stage was powered by a liquid-fuel rocket engine, second stage by a ramjet, third stage by an atomic rocket, and last three stages by liquid-fuel rockets. Russian journals are rich with technical stories on satellites, cosmic rockets, space stations, and other apparatus required for exploring space.

If the Russians are not already testing an atomic aircraft, chances are they will be doing so within the next two years. From all reports the first U.S. atomic plane will probably not be flying for at least five years. As for atomic rockets, the U.S. expects to ground-test an experimental nuclear-rocket reactor this summer and has already done radiation hazard studies. How soon such a rocket will be ready is not known.

Ehricke and many other U.S. space experts believe nuclear power offers greater advantages for space flight than does any other propulsion system, because it is fastest. Ehricke predicts that manned flights to Mars and Venus can be made by 1970, if we push our nuclear-rocket program. "We must do this," he warns, "if we are to be in a competitive position with Russia by that time."

MAJOR MISSILES IN THE U. S. AND SOVIET ARSENALS

	ICBM's	Range (in miles)	Power (lbs. of thrust)	When combat-ready	IRBM's	Range (in miles)	Power (lbs. of thrust)	When combat-ready
U. S.	ATLAS	5,500	365,000	July, 1959	THOR	1,500	150,000	NOW
	TITAN	6,500	365,000	1960-61	JUPITER	1,500	150,000	1959
					POLARIS	1,500	not final	1960
U. S. S. R.	T-4A	6,000	600,000	?	T-2	1,850	346,000	NOW
	T-3	4,000	800,000	NOW	GOLEM 1	395	120,000	NOW
	T-3A	6,000	850,000	?	GOLEM 2*	1,200	?	NOW
					T-1	400	78,000	NOW
					T-4	1,000	220,000	?
					CH-18	600	100,000	?

*Underwater version of T-2

NOTE: Information on Soviet missiles is based on non-official foreign intelligence sources. Data and combat-ready status must be regarded as general, rather than specific, indicating the huge Soviet outlay in missiles, rather than an exact rundown on individual missiles.

By **Edmund H. Harvey Jr.**

The mysterious motor of life

■ A plant is a living motor, but it's an odd sort of motor, indeed. It's the reverse of a man-made motor. A gasoline motor, for instance, uses fuel and produces energy and waste products. But a plant, which soaks in energy and consumes waste products, produces fuel.

The fuel a plant produces is the fuel of life — the oxygen we breathe and the food we eat. Without plants neither men nor animals could exist.

Plants produce food and oxygen by the process of photosynthesis. Scientists know a good deal about what happens during photosynthesis, but they don't know how it takes place. Researchers in labs in many parts of the world are now probing the mystery.

One of the most intensive research efforts is taking place at the Research Institute for Advanced Study (RIAS) in Baltimore, Maryland. There, research is being done by a twelve-man team that includes experts in biochemistry, biophysics, physiology, and electron microscopy. Though RIAS is supported largely by The Martin Company (aircraft, rockets, missiles), the research is basic — the goal being knowledge rather than practical applications or a marketable product.

In general, what happens during photosynthesis is this: Green plants use the radiant energy of light to convert water (from the soil) and carbon dioxide (from the air) into oxygen and glucose, a sugar. In the process, the oxygen is released into the air. The glucose, the basic building block of all foods, is stored in the plant cells. It is actually *stored energy* and is available to the plant for life and growth.

When an animal, say, a steer, eats a green plant, some of the plant's locked-in energy is released to "fuel" the steer. The rest of the energy is stored in the steer's body. Then, when a man eats a steak from the steer, he also benefits from the energy originally stored in the plant during photosynthesis.

But let's not forget the other product of photosynthesis, oxygen. It enables plants and animals to burn energy. Without oxygen, the stored energy could never be released.

Photosynthesis, by the way, is also responsible, directly or indirectly, for our important natural fuels: coal, oil, gas, and wood. When we burn any of these fuels for power or heat, we are actually releasing energy trapped by green plants — trapped, (except in the case of wood) thousands or millions of years ago.

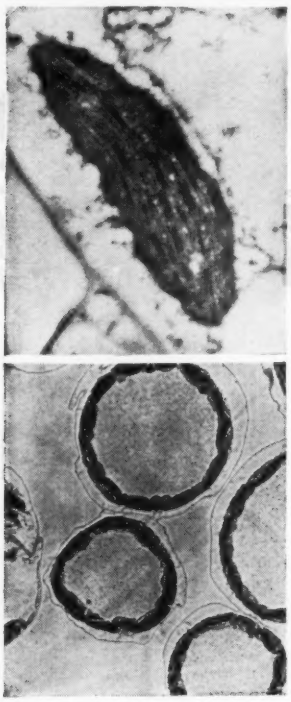
The star role in photosynthesis is played by a complex substance called chlorophyll. Dark green, chlorophyll gives plants their color. It is found only in chloroplasts — oblong bodies occurring in most leaf cells. It is chlorophyll that first catches the light energy that triggers the whole photosynthetic process.

Mystery No. 1

Photosynthesis involves two changes. One is a chemical change. Water is broken up into hydrogen and oxygen, and the freed hydrogen atoms are transferred to carbon dioxide, forming a sugar. This change sounds relatively simple, unless we know one chemical fact: both water and carbon dioxide are extremely stable compounds. Water has a steel grip on its hydrogen atoms, and carbon dioxide isn't the least inclined to accept the hydrogen atoms, once they are free from water. Yet light-excited chlorophyll can somehow shake a water molecule apart, and carbon dioxide can somehow be forced to accept the free hydrogen atoms. This can only mean, explains RIAS biochemist Dr. Albert Krall, that there must be some intermediate compounds and reactions by which hydrogen is more easily pulled off water and planted on carbon dioxide. What are these compounds and how do they do their job? That's mystery number one of photosynthesis.

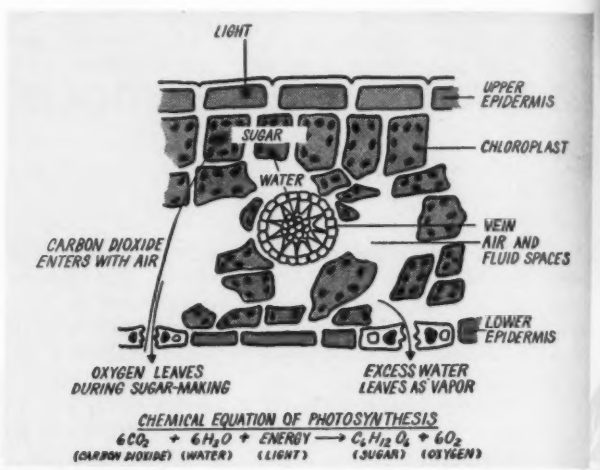
Mystery No. 2

The second change involved in photosynthesis is an energy change. The radiant energy of light is converted into energy stored in the



— Photos courtesy RIAS, Inc. Drawings by LoCurcio

CROSS SECTION OF LEAF (*below*) shows what happens during photosynthesis. Leaf uses light to convert water and carbon dioxide into sugar and oxygen. *Left:* spinach chloroplast, magnified 9,000 times (*top*) and spinach cells with chloroplasts, magnified 1,500 times.



plant cells. Some scientists believe this conversion of energy is 100 per cent efficient — that is, there is just as much stored cellular energy as there was original radiant energy. But most scientists think 35 per cent is more like the conversion efficiency. Even so, 35 per cent is amazingly high compared to the efficiency of man-made machines. How is a chloroplast "built" to produce such high efficiency? What in its structure makes it so excellent a converter of energy? That's mystery number two of photosynthesis.

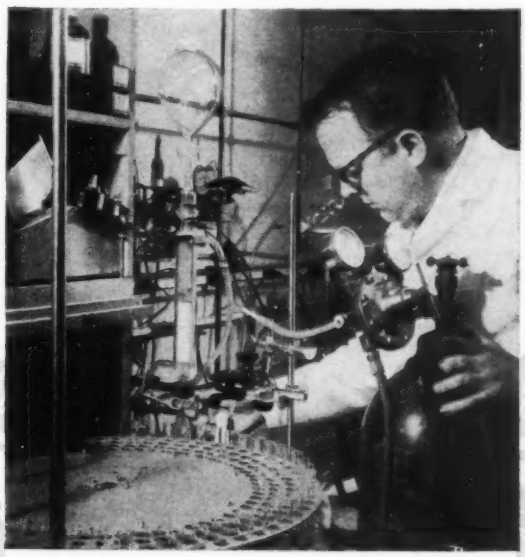
Trying to get "inside" a plant's chloroplast motor to see what makes it run has proved a formidable task for RIAS researchers. When a chloroplast is studied within a cell, for example, the activities of the chloroplast are extremely difficult to separate from the activities of the cell. And when chloroplasts are separated from the cell and suspended in a water solution, they don't operate like cell-bound chloroplasts. Some key substances always seem to be lacking from chloroplasts in solution. Such chloroplasts can't easily break down water into hydrogen and oxygen, and they have a great deal of trouble transferring the hydrogen atoms to carbon dioxide. The hydrogen tends to react with almost anything but carbon dioxide.

One of the ingenious ways scientists have devised to make chloroplasts in solutions act "natural" is this: a compound that will more readily accept the free hydrogen atom is substituted for carbon dioxide. At the same time, the scientists have tried to replace key substances apparently damaged or lost. This technique has proved fairly successful, reports Dr. Krall. Chloroplasts in solution have been found to be about as efficient as cell-bound chloroplasts.

One of the big benefits of such artificially controlled photosynthesis has been to give scientists a very close idea of just how, and what, cell proteins are involved in photosynthesis. And this, in turn, has brought Dr. Krall very close, so he hopes, to understanding and *naming* perhaps the most important intermediate compound involved in the transfer of hydrogen.

Another technique used by RIAS scientists is radioactive isotope tracing. Carbon-14, which is radioactive, is combined with oxygen. The resulting carbon dioxide is then "fed" to green cells. Under normal conditions, a tenth of a second elapses from the instant light hits chlorophyll until sugar and oxygen are formed in the cell. But a

MASS SPECTROMETER is used by Dr. George Hoch (*left*) to determine substances present during stages of photosynthesis. Dr. L. P. Zill (*below*) uses chromatography to separate substances found in the chloroplasts.



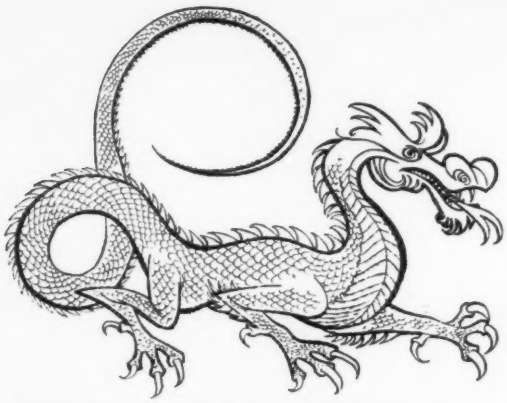
biochemist can slow down photosynthesis and halt it at almost any point he chooses by inactivating, or "washing out," a crucial enzyme. He then is left with a group of intermediate substances. Since the intermediates contain radioactive carbon, they can be spotted by a Geiger counter, separated, and analyzed. Repeated stopping of photosynthesis at different intervals will eventually show how carbon reacts throughout the photosynthetic process.

One of the really intriguing aspects of photosynthesis is chlorophyll's inability to use high, or even medium-high, light intensities. As RIAS plant physiologist Dr. B. Kok explains, plants can't use any light brighter than about 1,000 foot-candles. Yet, up to that level, brighter light makes the photosynthetic machine work faster: 900 foot-candles causes faster photosynthesis than 500 foot-candles, for example. But all the light between 1,000 and 10,000 foot-candles (where the intensity begins to destroy cells) is wasted. In fact, on bright summer afternoons, photosynthesis works rather inefficiently. Dr. Kok wants to find out why plants can't use brighter light to produce more oxygen and more food.

Where may all this research lead? There are a number of possibilities. Perhaps the most spectacular is the use of algae in spaceships to convert human wastes into oxygen and food by photosynthesis (see "The Spaceship's Gardener," March 24 *SW*).

A full understanding of photosynthesis could also be invaluable to us as the earth's population swells and as less and less land is available for farming. Algae may not be especially tasty, but it is one of the best photosynthetic motors going. An acre of algae, for example, might yield eighty tons of food — some fifteen times as much as today's average per-acre farm yield. One experiment now going on in Berkeley, California, involves growing algae on sewage ponds. From an economic standpoint, the idea looks unbeatable: cost is very low, necessary organic materials are already present in the sewage, the algae "crop" is abnormally large, and the sewage cycle is speeded way up.

Finally, there's the possibility that scientists might someday be able to construct artificial "photosynthetic motors" that would be far more efficient than green plants in converting light energy to stored energy. In other words, man might someday be able to make food from light, water, and air.



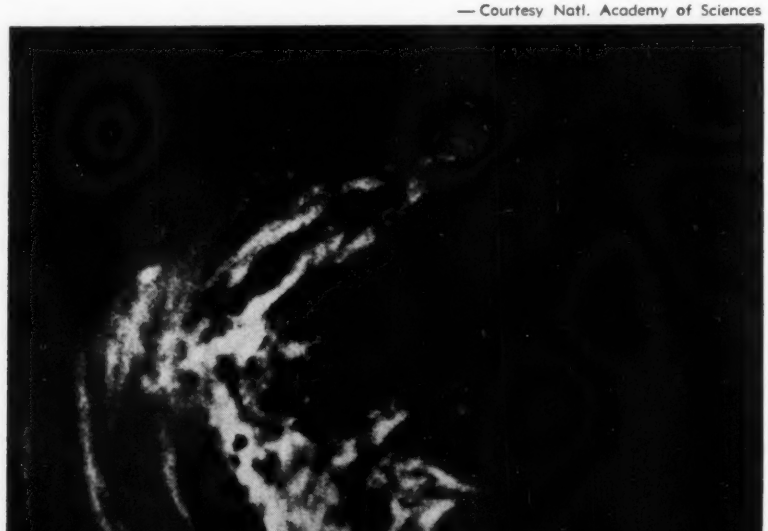
By John Brooks

The subtle storm

Auroras, visible effects of magnetic storms, suggested fiery dragons to the ancients. Today, scientists are probing their invisible effects

On February 9, 1958, a solar flare erupted, marking the start of what turned out to be one of the greatest magnetic storms on record. Magnetic storms are little-understood terrestrial disturbances that send compasses haywire, cause auroras, and disrupt radio communications. In this article, the second of three parts, the author describes what is known about magnetic storms.

— Courtesy Natl. Academy of Sciences



TELESCOPIC PHOTO of giant solar flare. The white spot represents size of earth.

PART II ■ Beyond much question, the presence of an aurora indicates that a state of electrical turbulence exists in the ionosphere, a region of ionized air that blankets the earth in a series of layers beginning about fifty miles up and continuing to over two hundred. Such turbulence, which invariably accompanies a magnetic storm, is of much more than academic interest; in fact, it is the direct cause of radio blackout, and radio blackout is by far the most troublesome practical consequence of this sort of storm. Under normal conditions, the ionosphere is long-range radio's staunchest ally. Without it, unrelayed radio signals could not be received more than a few dozen miles away, since they travel in straight lines and, owing to the curvature of the earth, tend to shoot out into space. The ionosphere, in its ordinary state, reflects the signals back to the earth, thus taking the place of an infinite series of relay stations. In a magnetic storm, the character of the ionosphere changes in such a way that it tends — particularly in the higher latitudes — to absorb signals, rather than reflect them. The resulting interruption of communication between distant points is the despair of radio engineers and the bugbear of lonely people on island outposts. Happily, a blackout never lasts longer than the magnetic storm that causes it, and often the ionosphere reconstitutes itself even before the storm is over.

Magnetic storms have other effects, too. Some of them have a remarkable ability — and this is probably what entitles them to their name — to do some of the same things that ordinary storms do. For example, by building up strong electric currents around an underground cable, they can set off circuit breakers designed to prevent an overload of current, and thus cut off a power line just as effectively as if a bolt of lightning had struck it. During a particularly bad magnetic storm on March 24, 1940, a cold, sunny day, electric service was temporarily knocked out in parts of New England, New York, eastern Pennsylvania, Minnesota, Quebec, and Ontario. The same day,

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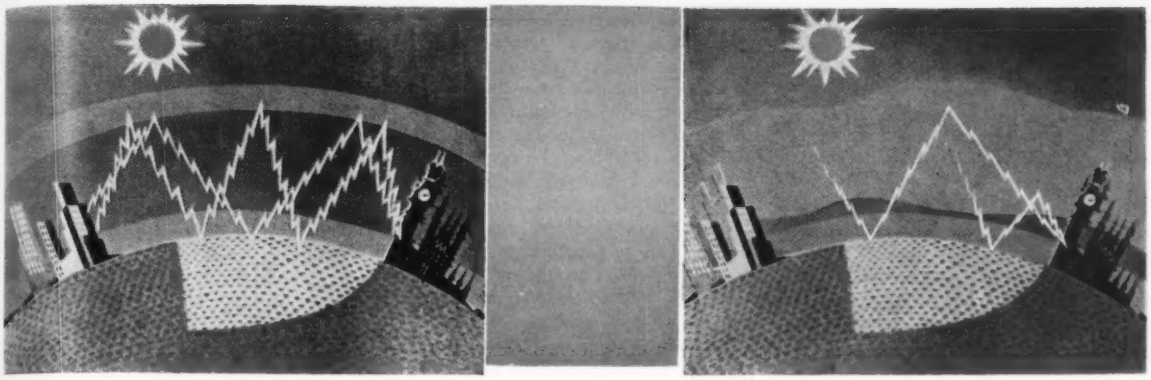
— Courtesy Bell System's "Our Mr. Sun"



RADIO SIGNALS normally travel by bouncing between the earth and the ionosphere, an atmospheric layer 50 miles up. But when the sun emits flares, the ionosphere becomes so disrupted that many signals are not reflected back to earth.

80 per cent of all the long-distance telephone lines out of Minneapolis were rendered just as inoperative as if the wires had been flattened by a blizzard, though the damage was less permanent. This storm also had an effect that neither lightning nor wind could have achieved — that of scrambling the letters in telegraph transmissions. Since March 24th happened to be Easter Sunday, a good many holiday greetings came through garbled beyond all decoding. Still, the storm was accompanied by inspiringly beautiful auroral displays, which may have compensated for its bad manners. One of the most frightening potentialities of magnetic storms — only theoretical, to date — is that in wartime they could activate the fuses of magnetic mines, which are designed to explode when they come close to a ship made of, or carrying, large masses of magnetic metals, like steel. Actually, none of the several strong magnetic storms that occurred during the most recent war in which magnetic mines were widely used — the Second World War — are known to have caused such explosions, but if any nation were to begin lacing the earth's waters with magnetically triggered nuclear bombs, such storms would abruptly cease being the merely pesky curiosities they are now and would become a menace to the survival of the race.

Magnetic storms are comparatively commonplace events, and severe ones occur about as frequently as severe North Atlantic hurricanes. Between 1874 and 1954, the Royal Observatory, in Greenwich, England, recorded a hundred and twelve that it considered big enough to be classified as "great." The two salient facts about those hundred and twelve are that they came in bunches — for example, there were none at all from 1886 to 1891, and then there were nine in 1892 — and that the bunches corresponded closely with the periodically recurring times when groups of dark spots on the sun's surface were largest and appeared most frequently. It is everywhere recognized not only that the maximum incidence of sunspots is cyclical but that the cycle extends over a period that may vary from nine to seventeen years and that averages out to slightly more than eleven. By projecting the curve of past cycles, astronomers had correctly predicted as long ago as 1946 that a sunspot peak would occur in 1957 and 1958; the period from July, 1957, through December, 1958, was accordingly picked for the International Geophysical Year, so that scientists could be on their toes for the spate of magnetic storms and other phenomena that were expected to accompany the dense accumulation of sunspots.

The unmistakable correlation between magnetic storms and sunspot peaks provides a clue to the storms' origins, but no more than a clue. The United States Coast and Geodetic Survey, which has studied the subject for years, because anything that affects the compass affects the reading of maps and charts, holds the opinion that no foolproof explanation of magnetic storms has yet been advanced. According to the most widely accepted theory, they are directly caused by the giant solar flares, like the one last February, that almost invariably occur at sunspot peaks. As for the spots themselves, which are hurricane-like vortexes on the sun's gaseous surface, a single group of them can be, like the one in Region ABOO, a hundred times the size of the entire earth, or even larger. Sometimes they emit flares and sometimes they do not, but only the flaring sunspots seem to give rise to magnetic storms. The larger flares are of almost inconceivable power. Dr. Harlan T. Stetson of the Massachusetts Institute of Technology wrote in 1947 that when a solar flare goes off, "in a fairly true sense an atomic bomb has exploded on the sun." The Doctor was quick to add that even the most destructive of nuclear weapons provides only a pale and inadequate analogy. Solar flares, the theory goes on, sometimes send out not only bursts of radio static, like those Dr. Maxwell detected, but also huge streams of submicroscopic, electrically charged particles — or, as up-to-date geophysicists prefer to call them, corpuscles. The radio bursts travel at the speed of light and are received on earth in eight minutes, but the corpuscles dawdle through space at a mere thousand miles or so a second, and it takes about a day for them to cover the ninety-three million miles from the sun. When a cloud of these particles engulfs the earth, so the theory goes, abnormal electric currents are set up in the outer atmosphere, and the result is a magnetic storm. As the solar particles approach the earth, it is believed, they are deflected by the earth's magnetic field toward its two centers of attraction, the Magnetic Poles. This, of course, would account for the fact that magnetic storms are at their most intense near the Poles and that the associated auroral displays — which are taken to be visual evidence of the impact of the solar corpuscles on the atmosphere — are seen most brilliantly in those latitudes.

The solar-explosion-and-solar-corpus-

cle theory is far ahead of any of its several competitors (last August 1st, the notion that a violent shock — celestial or terrestrial — can cause a magnetic storm got unexpected corroboration when, at roughly the time of a United States nuclear shot a hundred miles above the Pacific, instruments on Samoa recorded typical magnetic fluctuations; a brief aurora, clearly of artificial origin, appeared within one minute; and radio fade-outs were noticed locally for several hours), but because it has certain technical drawbacks, a few scientists are convinced that corpuscles cannot have anything to do with magnetic storms. These dissenters lean toward such other possible causes as ultraviolet radiation and, as in the case of Mr. Nelson, the planetary setup. The theorists do all seem to agree on the cyclical, and, specifically, the sunspot-cyclical, characteristic of magnetic storms, and it is this characteristic that has forced them — often reluctantly — into the study of similar cycles in natural history, economics, meteorology, and psychology. Much as astronomers would like to leave the investigation of such matters to less scientific sungazers — like the *Old Farmer's Almanac*, say — they cannot deny the existence of strong evidence suggesting that the sunspot cycle is related to all sorts of things. Tree growth in Arizona, measured by studies of annular rings, has been found to be fastest at sunspot peaks, and to have been so for hundreds of years. Canadian rabbits, Atlantic salmon, and meningitis cases in the United States have all been found to go through cycles, from prevalence to scarcity, that are approximately the same length as the sunspot cycle. Moreover, it appears that sunspots are related to meteorological as well as electromagnetic weather. There are more icebergs in the northern latitudes at sunspot peaks, while in the Temperate Zone precipitation tends to be abnormal and temperatures subnormal. A few years ago, a Harvard meteorologist, the late H. H. Clayton, tried to find a correlation between specific cold waves in the United States and specific solar events of the kind that often precede magnetic storms. He succeeded in establishing that, at least for the one North American season under study, the coldest weather in Minneapolis, Cincinnati, Boston, and Jacksonville tended to occur within five days after peaks in solar activity.

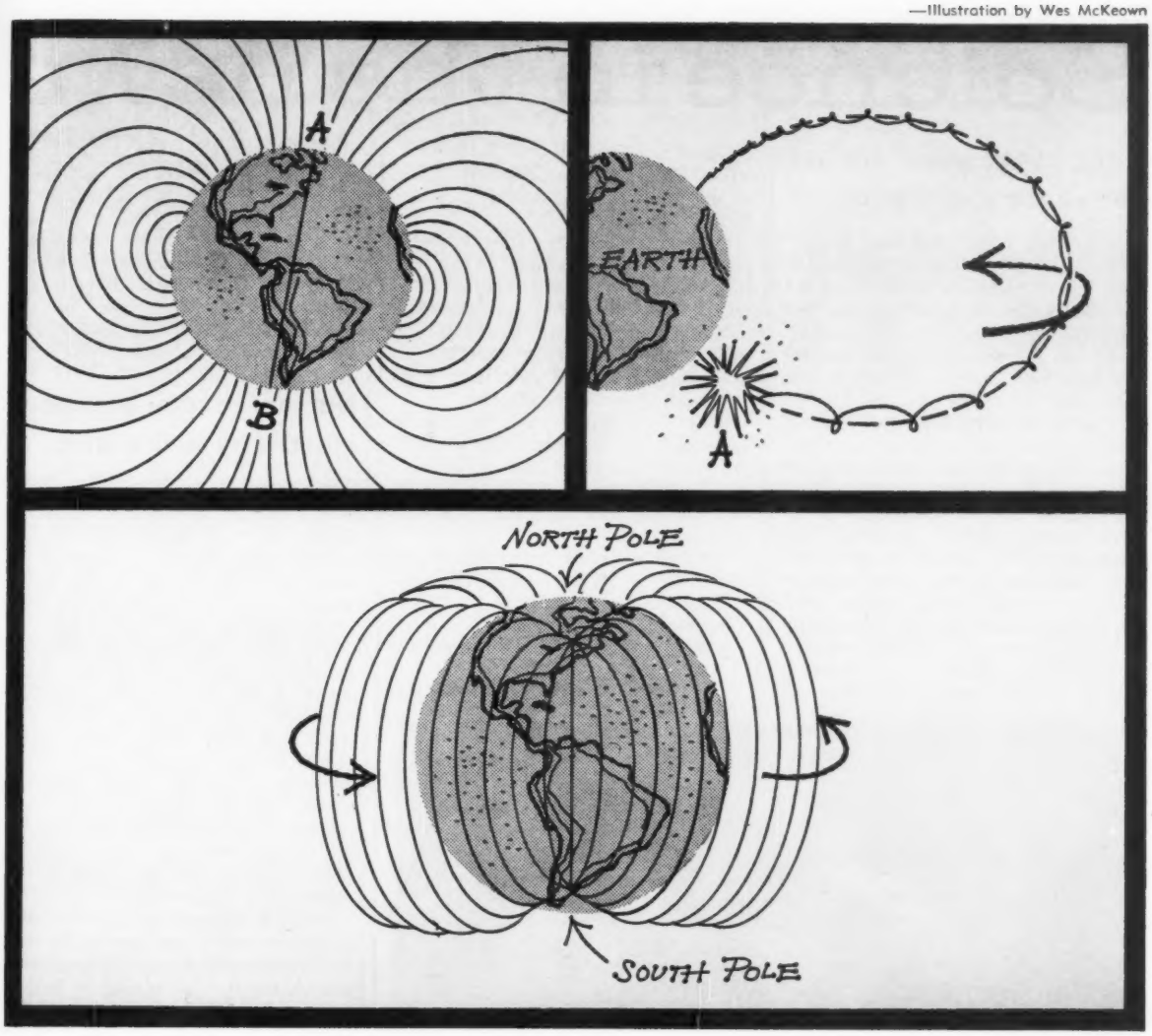
Earnest, if less conclusive, attempts, some of them dating back more than half a century, have been made to find sunspot-influenced cycles in the New York stock market. One favorite hypothesis holds that stock prices tend to be high when sunspots are numerous and low when sunspots are scarce; the explanation most commonly offered is that extra ultraviolet radiation, which is known to suffuse the earth and its atmosphere at sunspot maxima, makes people feel bullish, while the lower radiation level between peaks tends to reduce them to a melancholic, or stock-selling, mood. This theory works out strikingly well in the case of the sunspot (and stock-market) peaks of 1928 and 1937, as well as for the sunspot (and stock-market) low of 1933. It suffers a slight setback on the sunspot peak of 1946-47 — stocks were going down then, though they *had* hit a high early in 1946 — but is in better form on the 1957-58 peak, which, despite a deep dip in the middle, began and ended with market averages at or near record highs. Sunspots, it should perhaps be added, are expected to decline relentlessly over the next six or seven years.

As the late Mr. Clayton would surely have been quick to point out, the magnetic storm of last February occurred at a time when the central and eastern parts of the United States were suffering from the worst snowstorms and cold of the winter. In the three days ending on Monday, February 10th, at least forty-six people died as a result of the weather, eighteen of them in New York State, whose northern counties were contending with about three feet of snow and temperatures around zero. There was snow and freezing rain as far south as the Gulf states, and on Monday evening thick clouds over much of the eastern United States portended more snow. In New York City, where there had been light snow that weekend, Monday was clear but the temperature was far below normal, ranging between eleven and twenty-one degrees. As for the stock market, apparently it wasn't getting much nourishment out of Sunspot Region ABOO, since it declined on Monday, for the fourth session in a row.

Magnetically speaking, the day was exceptionally fine — ominously fine, in fact, since magnetic storms, like meteorological storms, are often preceded by lulls. This weather-breeding situation was recorded at the Coast and Geodetic Survey's Magnetic Observatory and Laboratory in Fredericksburg, Virginia, and at twenty-seven other Coast and Geodetic magnetic stations — ranging from the South Pole to Drifting Station A, on the northern polar ice, and from Guam to Puerto Rico — that were co-operating in the IGY program. Each station was equipped with magnetographs, designed to record automatically any fluctuations in the direction and intensity of the earth's magnetic field; these instruments were set up on sites that had been carefully chosen to avoid magnetic effects from local mineral deposits, and were housed in buildings made exclusively of wood, concrete, and other non-magnetic materials. All day Monday, the magnetograph needles throughout this hemisphere traced a steady, practically straight line across the graph paper, giving no indication that a vast solar-corpuscle cloud (to go along with the prevailing theory), moving along on a collision course with the earth, had now covered the greater part of the distance from the sun and was, by early evening in the eastern United States, a mere eight or ten million miles away.

The cloud blew in — or the earth moved into it, or the two events occurred together — at 8:26 P.M., Eastern Standard Time. The storm struck simultaneously — or at least within the space of less than a minute — at all the far-flung Coast and Geodetic observatories, and, it is fairly safe to say, all over the rest of the earth, too. At Fredericksburg, the magnetograph traces suddenly began describing a series of jagged peaks that looked like drawings of tall fir trees. The horizontal component of the magnetic field (that is, the pull of magnetism parallel to the earth's surface) suddenly showed a fluctuation of about a hundred gammas, or about one five-hundredth of the normal field strength. While this in itself is not a very serious variation, at the same moment the line showing the direction of earth magnetism also began to waver uneasily. The combination of readings showed unmistakably that a magnetic storm had begun and that more violent shocks could be expected. Since magnetographs are read only once a day and are otherwise left to themselves, nobody at Fredericksburg was immediately aware of what was happening to the traces, and it may well be that nobody at any of the co-operating observatories was, either. During the first couple of minutes of the storm, perhaps not a single human being anywhere took note of it. In its first phase, it was hardly severe enough to call attention to itself, except for a minor and not particularly unusual disruption of radio communication across the North Atlantic, noted at eight-thirty by both

—Illustration by Wes McKeown



INFORMATION RELEASED just recently describes effects of three A-blasts set off 300 miles above the earth by U.S. last September (Project Argus). Blasts produced auroras, just as magnetic storms do. An earlier shot, mentioned in text, had similar effects. Drawings show how A-blasts created a thin shell of radiation around the earth. Earth's magnetic lines of force *(top, left)* are believed to be arranged as though a bar magnet ran from A to B. A-blasts *(A in drawing at top, right)* emitted electrons that corkscrewed along lines of force and drifted eastward *(arrow)*. In an hour the electrons had formed a shell around the earth in the shape of the earth's magnetic field *(bottom)*.

the American Telephone & Telegraph Co. and the New York *Times*.

It was probably the sight of an aurora that sent some unknown scientist running to his magnetograph shack to be the first man to confirm the presence of the invisible storm, for a huge aurora was prompt in making its appearance. Of an unusual fiery red, it began, at about eight-thirty, to spread quickly from the auroral zones in the direction of the equator. It soon covered practically all of Canada and extended at some points into the southern reaches of the United States. In Minneapolis, where it had been dark about an hour, the aurora first appeared as a very intense green arc that extended up into the northern sky beyond the zenith. Then the green began yielding to patches of brilliant red. Not even the clouds that hung over a good deal of the eastern United States could blot out the aurora. At Ithaca, it was so bright that Dr. Carl W. Gartlein, head of the IGY Auroral Data Center there, could see a rosy glow coming through the overcast not only in the north but over most of the sky. At eight-fifty, the watch officer of a ship off the Georgia coast, in latitude 32 degrees, noticed that the northern sky was bright pink, even though the sun had set hours before. Auroras have a way, as mysterious as their other ways, of spreading wildly a few minutes before a great increase in the force of a magnetic storm, and certainly on this occasion the aurora ran true to form, because at one minute before nine, New York time, magnetic chaos broke loose from east to west and from Pole to Pole.

[*To be concluded in May 19* SW]

Science in the news

Long-range plans are set for space exploration

U. S. space plans came into sharper focus when the National Aeronautics and Space Administration recently outlined a ten-year space program. As part of the program, NASA named seven astronauts, one of whom will be the first American to ride a satellite into orbit.

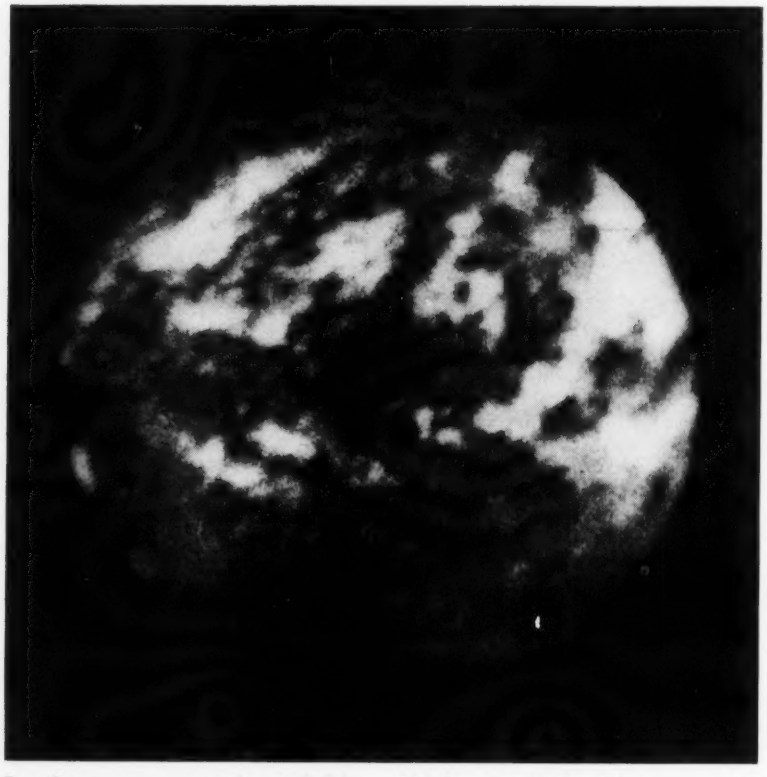
The seven astronauts were chosen after rigorous examinations to determine fitness. They averaged 34 years old, 162 pounds, and 5 feet 9¾ inches. One will be selected to circle the earth in a one-ton capsule. After two or three orbits at an altitude of 125 miles, he'll come down for a splash landing in the Atlantic Ocean. Subsequent flights will be lengthened. Eventually, two-man satellites will orbit for several weeks. After that come manned flights to the moon. This program is called Project Mercury.

Other parts of the ten-year space plan are equally ambitious. They call for: (1) setting up radio stations and telescopes on the moon; (2) collecting cosmic matter; (3) launching flashing-light satellites to enable scientists to map the earth more accurately; and (4) sending probes to planets.

This year, NASA plans to launch eight satellites and two space probes; next year, six satellites and four probes. The agency recently tried to launch two satellites with one rocket, but the attempt failed.

On the same day, the Air Force launched a 19-foot-long cylindrical satellite, Discoverer II, into a polar (north-south) orbit. This was a forerunner of reconnaissance satellites that will scan the earth with television cameras. Discoverer II was successfully stabilized in orbit, so that it did not tumble end over end. Reconnaissance satellites must keep pointed toward the earth. An instrument capsule in the satellite apparently returned to the earth somewhere in the Arctic. The Air Force hoped to recover it.

— Official U. S. Navy photo



Sun that man never sees is revealed in photo taken from altitude of 123 miles by special camera in nose of Aerobee rocket. Camera was fitted with mirror to filter out sun's glaring light. White blotches are clouds of hot gases, 4,000 to 6,000 miles above sun's surface. Dark areas are lower altitude gases. Light-sensitive cells were used to keep the camera aimed directly at the sun.

Nuclear reactor produces electricity in one step

Heat from an atomic reactor has been converted directly into electricity for the first time. Ordinarily, the conversion takes several separate steps. Scientists at the Atomic Energy Commission's Los Alamos laboratory were responsible for the achievement.

The direct conversion was done by a complex version of an old and rather simple device, the thermocouple. The principle of the thermocouple is this: when a junction of two unlike metals is heated, an electric current flows through a circuit connecting the metals. In the direct conversion of nuclear energy into electricity, uranium was used as one metal and cesium, in the form of a gas, was used as the other.

The Los Alamos scientists were able to convert only a tiny part of the heat produced by a standard nuclear reactor into electricity — just enough in fact, to light an ordinary electric bulb for twelve hours. But they believe that in time their system will power such vehicles as submarines and spaceships.

Trout in strange waters act strange indeed

A trout taken from its home often behaves foolishly — and loses its life.

Studies have shown, says a conservation official, that trout released into strange waters immediately search for new homes. If the fish aren't quickly successful, they literally run themselves to death in their search. Biological cause of death: a rise in the acid level of the trouts' blood, apparently resulting from the stress of the new environment.

The conservationist's conclusion: trout should be transplanted only to heavily fished streams just before the opening of fishing season. Otherwise, the fish will have died in vain.

Balloonists will study Venus from 80,000 feet

This summer, two men hope to study the planet Venus from a new vantage point. Floating in a balloon at 80,000 feet above the earth, they will try to discover whether there is water in the planet's atmosphere. If there is, it is possible that some forms of life may exist on Venus.

Ground studies have revealed an abundance of carbon dioxide in Venus's atmosphere, but little water vapor or oxygen. But the "picture" astronomers see from the ground, with the aid of telescopes and spectrographs, is distorted by the earth's own atmosphere. The balloon is expected to lift its passengers, a twelve-inch telescope, and spectrographic equipment above all but about 4 per cent of the earth's atmosphere. From there, the picture will be much clearer.

The balloon flight is expected to take about twenty hours. Aboard will be Dr. John D. Strong, experimental physicist at Johns Hopkins University in Baltimore, Maryland, and Commander Malcolm C. Ross, Navy balloon expert. The two men were unsuccessful in an attempted similar study of Mars last fall. A half-hour before take-off time, cold weather weakened the balloon's seam, causing it to split from top to bottom. A new type of balloon seam is expected to prevent such an occurrence on this flight.

Moon will be radio link between U.S. and Hawaii

Navy scientists will use the moon to relay military radio messages between Washington, D.C., and Pearl Harbor, Hawaii. The radio signals will complete the 460,000-mile trip from sending station to moon to receiving station in two and one-half seconds. Known as the Communications Moon Relay Project, the system is expected to be ready for operation in about a year.

The radio signals will be transmitted from saucer-shaped antennas eighty-four feet in diameter. The signals will bounce off the moon's surface and be picked up by similar antennas at the receiving stations.

Ordinarily, long-distance radio signals travel by bouncing between the earth and the ionosphere, an electrified layer in the upper atmosphere. But disturbances in the ionosphere (see drawing, page 15) often cause noise interference or radio blackout. The moon-relay system will not be plagued by this problem.

From a military standpoint, the system will have another advantage. It will be almost completely immune to jamming. Reason: the signals will be near the earth only at the transmitting and receiving stations. To jam the moon circuit, an enemy would have to set up a transmitting station a few miles from our transmitting or receiving stations, a highly unlikely possibility. Or he would have to bounce signals of the same frequency as ours off the moon. To prevent jamming by this method, the moon-relay system would simply change radio frequencies every few seconds.

Only one limitation mars the new system: radio contact is possible only as long as the moon is in sight of both sending and receiving stations. The time of contact will vary every day by from four to fourteen hours, depending on the orbit of the moon. But Navy researchers feel this limitation is far outweighed by the many other advantages of the moon-relay system.

Robot 'mechanic' works on atom plane engines

A robot called Handyman is doing the "dirty work" at the Atomic Energy Commission's National Reactor Testing Station near Idaho Falls, Idaho. Handyman is helping scientists to build an experimental atomic aircraft engine. The robot works on jobs involving amounts of radioactivity that would be fatal to man.

Developed by General Electric, Handyman is the first machine that incorporates the clutching motion of the human hand. Using the jointed thumb and forefinger of either hand, the robot can hammer a nail, put one object inside another, or unscrew a bolt. Stronger than the most powerful human being, Handyman is deft enough to pluck the petals off a daisy.

Handyman is operated by a man located outside the "hot" (radioactive) area in which the machine works. The operator wears a harness on his arms and hands. Movements of the harness cause signals to be sent to the robot. As the operator goes through the motions he wants Handyman to make, the robot duplicates them simultaneously. The operator closes his hand, for example, when he wants Handyman to clutch a hammer. Soon the operator will be able to see and hear what the robot "sees" and "hears" by means of a three-dimensional closed-circuit television camera and receiving set.

Possible future job for Handyman-type robots: they may be landed on the moon to explore that body by remote control.

News in brief

● A space gadget foreseen by science fiction has become a reality. A reactor gun has been developed to enable weightless space travelers to move around inside and outside their space craft. The gadget consists of a package of high-pressure air bottles connected to a short length of hose with a nozzle. The bottles are strapped to the spaceman's back. To go one way, he points the hose's nozzle in the opposite direction and presses its handle. A valve opens, and the rush of high-pressure air from the nozzle propels the spaceman.

● Scientists are discovering that Antarctica is full of surprises, plus a mystery or two. A ground party in search of a mountain range charted by aerial survey found that the range wasn't where it was supposed to be. And when the scientists finally located the range, some sixty miles away, they discovered that it had ten mountain peaks instead of the five previously reported. They also found a sprinkling of volcanic rocks along the ice sheet near the peaks, indicating relatively recent volcanic activity. But they found no active volcanoes. How did the rocks get there? The scientists don't know.

● Russia may develop a satellite to relay television broadcasts. A Soviet plan calls for placing a satellite in a "hovering" orbit some 22,400 miles from the earth. At that distance the orbit would be so big that the satellite would take as much time to make one circuit as the earth takes to rotate once. In other words, the satellite would always stay over the same portion of the earth — in the Russian plan, roughly above Indonesia. In that location, say the Russians, the satellite should be able to relay TV broadcasts to all points in Russia and probably throughout most of the world.

● Scientists may declare nuclear war on the tsetse fly of Africa. This insect carries the human and animal disease of sleeping sickness. The weapon will be atomic radiation. It makes insects incapable of reproducing.

● A gigantic hi-fi set is testing the ability of missile parts to withstand the vibrations of space flight. At Lockheed's missile and space division in Sunnyvale, California, a 10-ton, 200,000-watt amplifier causes sound vibrations that shake missile parts. The parts are jarred — until destroyed, if necessary — to determine how much punishment they can stand. The amplifier is about 20,000 times as powerful as the ordinary home hi-fi set.

ORIGINALITY IN PROJECTS

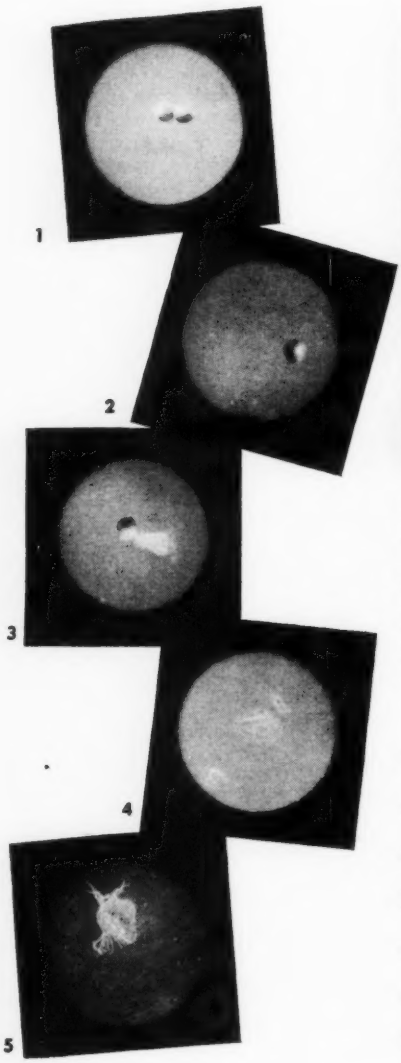
Young scientists

Linda Carolyn Wood, Mullens (W. Va.) High School

Alexandra Jagiello, Perry (N.Y.) Central Schools

Theodore Benjamin, Editor

Effects of filtered sunlight on the growth of brine shrimp



LINDA CAROLYN WOOD. Microphotographs *(left)* of her project show stages in development of brine shrimp: (1) egg before being put in water; (2) splitting egg, with young shrimp coming out; (3) young shrimp leaving egg; (4) young shrimp in membrane; (5) free swimmer.

Originality and creativity rank high on the checklist of a science-fair judge. Here are two projects, each of which deals with a basic topic that has been given a unique twist

■ In the November 25, 1958 issue of SCIENCE WORLD we described the methods by which a fascinating little organism called *Artemia salina* (brine shrimp) could be cultured. Dried, resting eggs of brine shrimp are stocked by pet shops as food for tropical fish. The eggs may be conveniently hatched by placing them in a cup of water to which half a teaspoon of table salt (non-iodized) is added. Within one or two days, the eggs hatch into larvae and shortly thereafter develop into adults. Food can be supplied by adding a small amount of yeast suspension to the culture water.

The free-swimming brine shrimp make an excellent object for microscopic study. But last year Linda Carolyn Wood, now a ninth grader in the Mullens (W. Va.) High School, was struck with the idea that these organisms could be used for an experiment in an area she was interested in. She had been experimenting with the growth and development of plants in various colors of light and had shown that color could affect the growth of plants. She saw the wonderful possibility of using brine shrimp in a similar experiment. Together with Mrs. Dora M. Lewis, her eighth grade science teacher, she planned her project.

She obtained some small vials and wrapped each in a different color of cellophane — green, red, purple, and yellow. The vials were filled with equal amounts of salt water and about the same number of eggs were deposited in each. Finally, the vials were placed in the window where sunlight could reach them. A vial wrapped in clear cellophane that admitted white light was used as a control.

Linda watched each vial and re-

corded the rate of hatching and growth. In three separate trials she found that, compared with the vial admitting white light, the hatching process was definitely accelerated by the light that penetrated the green cellophane. The eggs in the vials covered with red cellophane were next in order; it was also noted that in these vials the shrimp grew larger and were more active. The light filtering through the purple cellophane promoted the hatching process to a limited extent. Little, if any, increase over what occurred in the white vial was noted in the yellow.

Armed with these results, Linda was ready to begin work on the things she would use to present her project. She prepared a short life history of the brine shrimp, which included drawings of the stages of development. This material was mounted on either side of a center panel that contained the title of the project and an eye-catching seashore scene.

She prepared microscope slides of the various stages of development and, with the aid of a photographer friend, secured some fine microphotographs. These were mounted on pieces of poster board and properly labeled. The microscope and slides were mounted in the foreground of the exhibit. In a row of glasses, each covered with a different color of cellophane, she exhibited cultures of live brine shrimp. A typewritten copy of her project report — including descriptions of her procedure, observations, and conclusions — rounded out her exhibit. Linda's project won first place and a special award for the Junior High division of the Region III West Virginia Science Fair at Bluefield (W. Va.) State College.

A study of corrosion

■ Whenever two unlike metals are placed in a solution of acid, base or salt, an electric current flows if the metals are connected together. This is the source of the electricity produced by cells and batteries, and it is a principle that has given us convenient sources of electrical power.

As current is produced by a cell, the negative electrode is eaten away. For it is at the negative electrode that the chemical process which supplies the energy the cell produces goes on. When the zinc electrode in a dry cell is completely eaten away, the cell ceases to produce electrical current; you have obtained from the cell all the electrical energy it is capable of producing.

But this principle of electrochemistry, called galvanic action, has its less desirable side. Two different metals in intimate contact in a solution of acid base or salt (such a solution is called an electrolyte) will continuously produce a tiny electric current. As a result, the metal that acts as the negative electrode will eventually be eaten away. As you know, this eating away is corrosion.

Alexandra Jagiello, a student in the Perry (N. Y.) Central Schools, became interested in a study of corrosion when the topic was discussed in her chemistry class. She decided that she would carry out a project on the cause and prevention of corrosion. Recognizing that a major cause of corrosion lies in the difference of potential produced by dissimilar metals joined together in an electrolyte, she studied corrosion caused by galvanic action.

With the help of Marian E. Russell, her chemistry teacher, Alexandra prepared a project which was to win for her a prize at the Fifth Annual Central Western Zone Science Congress held at Brockport, N.Y.

She began by collecting and preparing the metals she intended to use. She decided to try the effects of an electrolyte on the following: iron nails partly copper plated, iron nails partly tin plated, unplated iron nails, aluminum nails, iron nails covered by aluminum foil, and iron nails partly plated with zinc. In plating the nails she plated some at one end only, others at both ends, and still others at the center. (For more on electroplating, see *SW* April 21, p. 20.)

Alexandra hit upon a most spectacular way of demonstrating the electrolytic action on each of the nails. She prepared an agar-agar gel containing 3 per cent sodium chloride, 5 per cent potassium ferricyanide and 1 per cent phenolphthalein. Each nail was placed in a Petri dish and the melted agar solution poured over it. When the agar solidified, the nail was embedded in the electrolyte.

The sodium chloride in the agar acted as the electrolyte. The potassium ferricyanide indicated the presence of ferrous ions by turning the agar blue; the phenolphthalein indicated the pres-

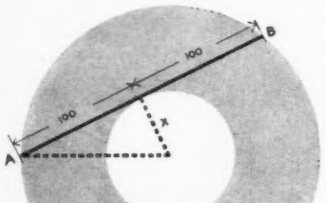
[*Continued on p. 23*]

— Photo by Clark Rice

ALEXANDRA JAGIELLO explains her project on corrosion, which won her science prize.

On the light side

Brain teasers



Circular track

If the longest straight line that can be drawn on a circular race track (line AB in the figure above) is 200 yards, what is the area of the track? No more data is needed for solving this remarkable problem. The dotted lines are hints for the solution.

Elliptical track

If the inside of a race track is an ellipse, will the outside of the track be an ellipse also? Assume, of course, that the width of the track is constant.

Low finance

A troubled depositor asked to see the president of his savings bank. "In some way I don't understand," he said, "I seem to have overdrawn my account. Originally, I had $100 in the bank. Then I made six withdrawals, totaling $100. But look." He held out a paper showing these figures:

Withdrawals	Amount left on deposit
$50	$50
25	25
10	15
8	7
5	2
2	0
$100	$99

"So you see," said the depositor, "I seem to owe you $1." The bank president thanked the man, but soon set him straight on his error. Can you spot the error? (See Answers.)

Find your picture

The illustration below is reproduced from an old puzzle book. To see your portrait in the mirror, pick up the magazine, close one eye, and with the other sight along the page from its bottom edge.

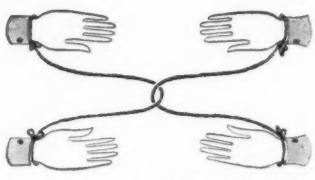
The laws of perspective distort, so to speak, the distorted drawing, bringing its proportions back to normal. When a mural is painted on a high wall, the artist has to make a similar distortion of his figures in order to compensate for the foreshortening that results from looking upward at the mural.

Tangled couples

The study of knots and linkages belongs to a branch of geometry called topology. Here's a topological puzzle that makes an entertaining party game.

Divide the guests into couples. Each couple ties a piece of string to their wrists, with the two strings linked together as shown. A prize goes to the first couple to unlink themselves without cutting or untying the cord.

Perhaps you saw this puzzle demonstrated on the Jack Paar TV show last year. Jim Moran, the publicist, was using the puzzle to explain topology to Jack. But Jim forgot the solution and finally had to cut the cord after he and Jack had struggled hopelessly for ten minutes.



— Drawings by LoCurcio

The puzzle is solved by passing the center of one string under the string around the other person's wrist, then over his hand, then back under the string again. — GEORGE GROTH

Answers

CIRCULAR TRACK: Let x be the radius of the small circle. The radius of the large circle is clearly the hypotenuse of a right triangle with sides of 100 yards and x. Therefore, we can express its length as the square root of (x^2 plus 100^2). The area of the track is the area of the large circle minus the area of the small one. When you work this out algebraically, you will discover that all the terms containing x politely cancel out, giving an answer of pi $\times$ 100^2, or about 31,416 square yards. Given the length of the longest straight line, the area of the track is constant, regardless of the track's width or the dimensions of its inner and outer circles!

ELLIPTICAL TRACK: The outside of the track will be oval-shaped, but not a true ellipse.

LOW FINANCE: There is no reason whatever why the original deposit should equal the total of amounts left after each withdrawal. The near-equality in this case is just a coincidence.

Originality in projects

(Continued from p. 21)

ence of hydroxyl ions by turning the agar pink.

The existence of the positive and negative electrodes on the surface of the bi-metallic nails was thus demonstrated by changes in color of the reagents. If phenolphthalein turned pink in the vicinity of one of the metals, that metal was the positive electrode. Also, potassium ferricyanide is a reagent that produces a blue color by reaction with ferrous ions such as are formed at the negative areas when iron corrodes. The appearance of this blue color demonstrated the existence and location of the negative terminal on the iron.

When Alexandra placed an iron nail with the copper plate on the pointed half of it in the prepared gel, a pink area developed around the copper-plated portion and a blue area around the bare iron half. The colors became more noticeable with time. This showed that iron continued to corrode as the negative electrode, and there was an increasing number of hydroxyl ions at the copper positive electrode. When the iron nail whose pointed end was plated with zinc was placed in the same gel, the iron acted as the positive electrode and the zinc as the negative electrode. This time, the pink color indicated the positive terminal at the iron half. Since no iron went into solution here, no blue color developed. The zinc corroded and provided protection to the iron. A white area developed around the zinc, probably because of a compound of zinc. Thus, by noting the different patterns of coloration in the gels, the nature of the electrolytic action could be determined.

From her experiments, Alexandra understood that prevention of corrosion is largely a matter of preventing the formation of an electrolytic cell. She learned that certain metals are more active (electronegative) than others. In fact, her experiment helped her and her classmates understand the origin and value of the Electromotive Series, a listing of elements in order of decreasing chemical activity.

Since Alexandra was to demonstrate her project for the judges, she prepared a chart showing the simple chemical reactions that took place. To this she added a display of the basic materials of her project, together with samples of the various metals in the specially prepared agar. When she presented her study, the judges could not help but be impressed with the uniqueness and thoroughness of her work.

WHAT WILL TOMORROW'S TELEPHONES BE LIKE?

In the picture above you see models of some of the new telephones that the Bell System is testing for future use. They're all quite different in many ways from present phones, and now we're finding out how well they work in practice.

One of them, you'll notice, has the dial in the handset. Another has no dial at all. Calls are made by pushing buttons.

Still another has no handset to hold to the ear. A small microphone picks up your voice, and a small speaker lets you hear the person you're talking with.

These are experimental models, of course. If they are offered to the public they may look somewhat different.

One of our big jobs is making sure that our customers get the best, most advanced and modern equipment that we can give them. This is one of the many ways that we keep improving your telephone service—by working today to perfect the telephones of tomorrow.

The "CALL DIRECTOR." This is a brand-new push-button telephone for offices, designed to speed communications for the nation's business people. Now available, the Call Director is the result of years of careful research and development.

BELL TELEPHONE SYSTEM

Paul Rubin of Seattle, Washington, writes:

Do whales suck in water and then spout it out?

No. It is a common misconception that a whale takes water into its mouth and spouts it out through its blowhole (a nostril located near the crown of its head). But this is impossible, for there is no passage connecting a whale's mouth with its nose. Actually, a whale spouts air containing water vapor. Before diving, a whale takes into its lungs large amounts of air through its blowhole (some whales have two blowholes). The air becomes heated and saturated with moisture inside the whale's body. When the giant mammal rises to the water's surface, it opens a valve in its blowhole and expels the air. As the whale's breath is discharged, it comes in contact with the colder sea air, the water vapor condenses, and a visible spout is formed.

Robert Healy of Port Allegany, Pennsylvania, writes:

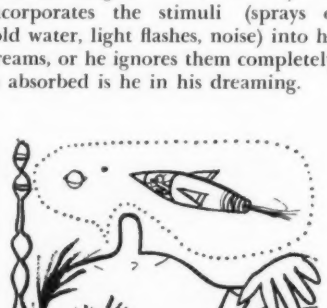
What is a photo cell, and how does it work?

A photo (or photoelectric) cell generates an electric current when exposed to light. There are several types of these cells, but their principle is the same. A photosensitive material — one highly sensitive to light — is placed close to (or in contact with) a metal conductor. Both are connected in a circuit. When light strikes the material, electrons are jarred loose, move to the conductor, and flow through the wire. When electrons flow, the result is a current of electricity. As the intensity of light increases, the flow of current increases. The light-meter used by photographers consists of a simple photoelectric cell and an ammeter. The ammeter measures the flow of current generated by the photo cell and thus indicates the intensity of light striking the cell. Further details on photoelectricity can be found in most physics textbooks.

Diana Shaw of Oak Park, Michigan, writes:

Why do we dream?

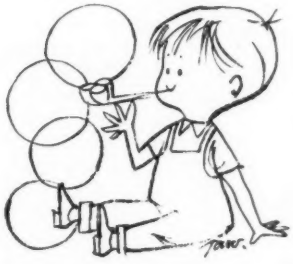
Many scientists agree that the function of dreams is to safeguard sleep. This is extremely important, since tests have shown that animals die more quickly from lack of sleep than from lack of food. Dreaming can be detected in a sleeping subject by using an electroencephalograph (EEG) to measure his brain's activity. Tests with this machine have shown that a person dreams only when he is sleeping lightly. Scientists think that when a stimulus, such as noise, jogs a person from the deepest levels of sleep, his brain stops the wakening process by dreaming. EEG lab tests have indicated that a person unconsciously fights off awakening in one of two ways: he incorporates the stimuli (sprays of cold water, light flashes, noise) into his dreams, or he ignores them completely, so absorbed is he in his dreaming.



James H. Bass of Huntsville, Alabama, writes:

Why are bubbles round?

Bubbles usually consist of small portions of air or other gas surrounded by liquid. They are round because of the surface tension of the liquid. Surface tension is the tendency of molecules in the surface layers of liquids to draw together. In doing so, they form a kind of skin that "tries" to shrink to the smallest dimension it can. The shape that has the smallest surface area in relation to volume is a sphere. So a bubble tends to be spherical — or round.



Glyn Huff of Outing, Minnesota, writes:

Last winter, I saw tiny black insects hopping around on the snow. I was told they were snow fleas. Is there such a thing?

Yes. Snow flea is their popular name, but they aren't true fleas. They are members of the springtails, a wingless group of insects whose scientific name is Collembola. They are called springtails by zoölogists because they have an appendage under their abdomens that acts as a springboard for hopping. There are many species of springtails. They range in color from white to black. The black insect you saw was probably *Achorutes nivicolus*, a species found all over the United States. *Achorutes* lives in vegetation under the snow and emerges only on warm days. When the temperature drops, the springtail goes back under the snow.

Questions from readers will be answered here, as space permits. Send to: Question Box, Science World, 575 Madison Avenue, New York 22, N.Y.

By Jules Bergman

The Comet comeback

Disaster struck Britain's pioneering Comet jets, apparently knocking Britain out of the jet age.

But from the tragedies have come better and safer jets, both in Britain and in the U.S.

Stranger than fiction

■ Five years ago Britain's aircraft industry, which had pioneered the jets in commercial aviation, was struck by disaster. In less than ninety days, two of de Havilland's proud new Comet pure-jet transports disintegrated in mid-air over the Mediterranean, with hardly a clue to what had happened.

Comet G-ALYP (Yoke-Peter) exploded in mid-air south of the island of Elba shortly before 10:00 A.M. on January 10, 1954. Moments earlier, it had reported in from 27,000 feet over an Italian airways radio beacon. Another British aircraft, which had been talking to the ill-fated Comet, reported the only possible clue — a message broken off in mid-sentence. Farmers on Elba heard an explosion and saw the flaming wreckage. Italian harbor authorities raced to the scene. They were able to recover fifteen bodies, mailbags, and some of the wreckage. Thanks to their prompt arrival, the crash area was marked.

Immediately after the news reached London, British investigators were on their way to Elba; the British Navy was called in; and one of the greatest pieces of salvage-detective work in modern history was under way.

Italian doctors, on their own, established that death, in the case of the fifteen bodies recovered, had been caused by impact against parts of the Comet. They found that explosive decompression and deceleration had caused major injuries. Pressurized like all modern high-altitude aircraft for both safety and comfort in thin air, the Comet had somehow burst open, killing all aboard in a split second. With this clue, a flotilla of salvage vessels went to work. The water was 70 to 100 fathoms deep (a fathom equals six feet), and the painstaking salvage took more than eight months. By the end of August, 1954, about 70 per cent of the Comet had been recovered and shipped to England for study.

After the accident, British Overseas Airways Corporation had immediately suspended its Comet jet service. Possible causes of the tragedy were minutely gone into. Metal fatigue (which, it later turned out, had occurred in the main cabin) was considered chiefly in terms of the Comet wings, because of cracks which had appeared near the wheel-wells. Many modifications were made in the Comet after these reexaminations, but fire was still regarded as the basic cause of the accident.

The Comets, meantime, went back into service in late March. Reconstruction of Yoke-Peter was still going on at the Royal Aircraft Establishment in Farnborough.

If, looking back, it seems that the British were incautious about the possible failure of the Comet's main cabin, it should be remembered that de Havilland had tested the strength of the pressurized main cabin 18,000 times in static tests. Of these, 15,000 pressure tests were intended to cover the life of the aircraft — the equivalent of 15,000 flights; de Havilland then added 3,000 extra tests. In these tests, the cabin had been subjected to differential pressures between high-altitude flight and interior pressures (8.2 lbs. per square inch) — what was expected at the Comet's 35,000-foot operational altitudes. The tests did finally produce a skin failure — at the corner of a window, where the cabin had suffered a small defect in its aluminum skin during manufacturing. But so many pressurizations had been safely completed that the Comet was passed.

Everything had been proved in the laboratory; and the Comet fleet of BOAC had already flown almost 25,000 hours, or nearly 10,000,000 miles. So metal fatigue — literally a wearing out because of atmospheric turbulence and other conditions — was largely forgotten.

Then, while the reconstruction of Yoke-Peter was still taking place, its sister ship Comet G-ALYY (Yoke-Yoke) crashed in the Mediterranean. Yoke-Yoke had apparently exploded in mid-air as it was climbing to 35,000 feet after leaving Rome. Some bodies and wreckage were recovered. But, in water between 520 and 580 fathoms deep, salvaging the rest of the wreckage was impossible.

Examination of the bodies produced evidence of a disaster identical to that of Yoke-Peter.

All Comet service everywhere was suspended; Britain's proud Comet was jinxed — a black sheep in aviation, destined for the junk heap.

Investigation moved forward swiftly.

Reconstruction of the salvaged wreckage of Yoke-Peter continued. And a sister ship of the ill-fated Comets was placed in a huge water tank for repeated pressurization tests. (A water tank was used because the force of the fuselage rupturing in open air was calculated to equal that of a 500-pound bomb: this was far too dangerous for laboratory handling.) With the fuselage of the Comet in the tank and its wings projecting outward through water-tight seals, the plane was then put through the same kind of loads and stresses encountered in actual flight. First the wings were flexed by hydraulic jacks, simulating thousands of flights in a short span of time. Then attention turned to the main cabin itself. After many pressurization tests, the cabin failed at the corner of a window. The window was repaired, and the tests begun over: a window again failed. Now they knew a window *could* have failed; but none of the windows thus far salvaged had failed. The trick was to find the fatal window (if it existed) somewhere on the bottom of the Mediterranean. This was accomplished by an ingenious method.

Model Comets — exact reproductions of the jet — were assembled and set to explode in mid-air as Yoke-Peter had. The fall of their wreckage was mapped. Data from the model tests sent the salvage vessels back to the job, retracing the flight path of Yoke-Peter. And, about where the models had indicated, the cabin section containing the critical window was recovered. It had failed, thus rupturing the entire cabin in a fraction of a second, killing all aboard, and sending the proud Comet into the sea.

The Comet 1 was washed up, but de Havilland, refusing to quit, pursued the Comet project. With lessons learned from the tragedy, a new Comet was born — stronger, safer, faster, longer-ranged. The British put four more years of testing and research into the project before emerging with the Comet 4. They were finally convinced that they had produced a fail-proof jet transport.

The de Havilland company's experience in pioneering pressurized jet aircraft came as Boeing, Douglas, Lockheed, and Convair were forging ahead with their own projects for pure-jet and prop-jet transports. The four American firms, with the active assistance of the National Advisory Committee on Aeronautics (now the National Aeronautics and Space Administration), laid out the most rigorous testing program aircraft firms had ever imagined. They knew now that high-speed, high-altitude jet flight was not just an extension of slower, lower-altitude flight. It was a new dimension in aviation. It possessed unknowns and special dangers — as de Havilland had ruefully discovered.

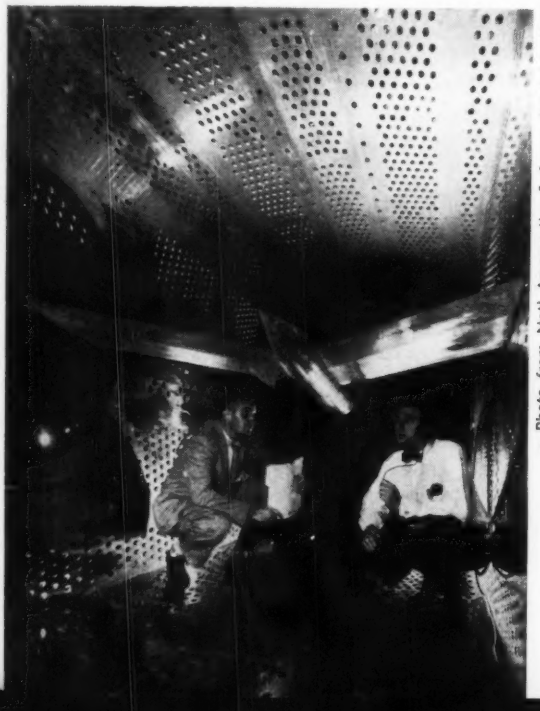
Boeing already had jet experience. It had turned out the B-52 jet bomber and the KC-135 jet tanker. (The latter is a military version of the 707.) It had begun its design and wind-tunnel tests of a jet transport back in 1943.

Designs for the 707 were subjected to 24,000 hours of wind-tunnel testing. To perfect the jet's design, more than 15,000 hours of experimental flying were done with large jets. Boeing set up a huge water tank — for hydrostatic testing of the 707's fuselage — and ran 50,000 pressurized test cycles; this was the equivalent of more than 70,000,000 miles of actual flight. Each of these tests simulated a six-hour flight — complete with runup, take-off, climb to altitude, letdown, and landing. Still not satisfied, the engineers put the pilot's cabin into the tank and ran 70,000 "flights." Remembering the grim Comet lesson, they selected at random a 707 passenger window and 507,600 times subjected it to a 10-pound-per-square-inch differential pressure. (Normal maximum flight pressure is 8.6 psi.) The window also was triple tested

— Photos from B.I.S.

FROM WRECKAGE of Comet that exploded south of island of Elba, crash investigators pieced together rear fuselage and tail unit *(far left)*. They also subjected a sister Comet to repeated pressurization tests in huge water tank. These tests resulted in fuselage failure *(left)*, pointing the way to the actual crash cause and the development of a safer aircraft.

COMET CRASHES pointed up dangers of pressurized jet aircraft and prompted American jet firms to undertake testing programs more rigorous than any before. Aeronautical researchers shown below are checking aircraft model in wind tunnel of National Aeronautics and Space Administration. Air flows through tunnel at supersonic speeds.

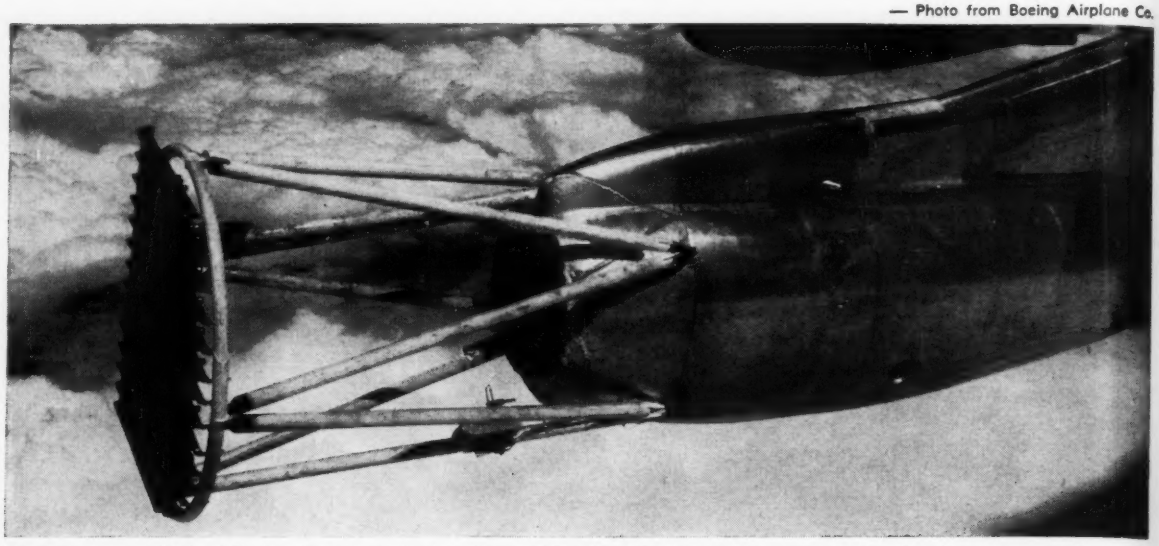


— Photo from Natl Aeronautics & Space Administration

— Photo from BOAC

COMET PURE-JET TRANSPORT takes off from airfield. Two major disasters almost put Comet on the skids, but painstaking research enabled it to stage a comeback.

— Photo from Boeing Airplane Co.



IN ICING TEST at high altitude, device attached to front of Boeing 707 jet engine sprays water that freezes on engine.

— up to 25.8 psi. for five minutes — and passed without damage.

Before the 707 was allowed to enter airline service, Boeing jet transports had accumulated more than 200,000 hours in the air. During flight tests the whole story of the plane's stresses and strains had been recorded on an oscillograph film and hundreds of other instruments.

Its ability to take sudden shocks and strains was tested. The leading-edge flaps of the 707 were wind-tunnel tested and flight-tested for eighteen months on the 707 prototype. The plane's oversized nose gear was treated to a total of 13,000 simulated landings.

The Civil Aeronautics Administration specified ultra-tough engine-icing tests for jet transports to be sure they would not flame out under any conditions. An airborne icing machine was rigged ahead of one of the 707's jets. At 22,000 feet, with an outside air temperature of — 20° F., the ice was turned on. Some of the ice went back through the engine, where it was chewed up by the compressor blades and vaporized. Ice formed on the leading edges but broke away when the engine was accelerated. The 707 passed the icing tests with flying colors.

Douglas, whose transports have long dominated world markets, set up its own testing program for the DC-8 jet. It ran 120,000 underwater pressure tests on the DC-8 fuselage. Then, to further prove the DC-8's fail-proof design, engineers fired a 15-inch-wide triangular spearhead from a gas-loaded gun into the plane under full pressurization and gust-loading. Repeated gun tests failed to produce any significant crack growth. Where cracks did enlarge, they were stopped completely by a special rip-stopper structure built into the DC-8 frame.

At the CAA's Indianapolis test station, a DC-8 nose section was subjected to bird tests. These call for a four-pound bird to be fired along the flight path into the window at 391 miles per hour. The DC-8 windshield took the impacts up to 461 mph.

Testing the DC-8's great wings, jacks were applied, forcing them up nearly six feet beyond normal position and down 3½ feet below normal position without damage. Loads on the wings were forced up to 462,000 pounds — nearly twice the design gross weight — without causing structural damage.

Electrical vibrators, tuned in steps to 35 different frequencies, were applied to 400 points of the DC-8 to produce vibration data.

Combating a special hazard of jet engines — runway dirt and debris sucked into the turbines — Douglas turned out a blowaway deflector. The deflector bled high-pressure air from the jets and aimed it downward to deflect debris in the plane's path.

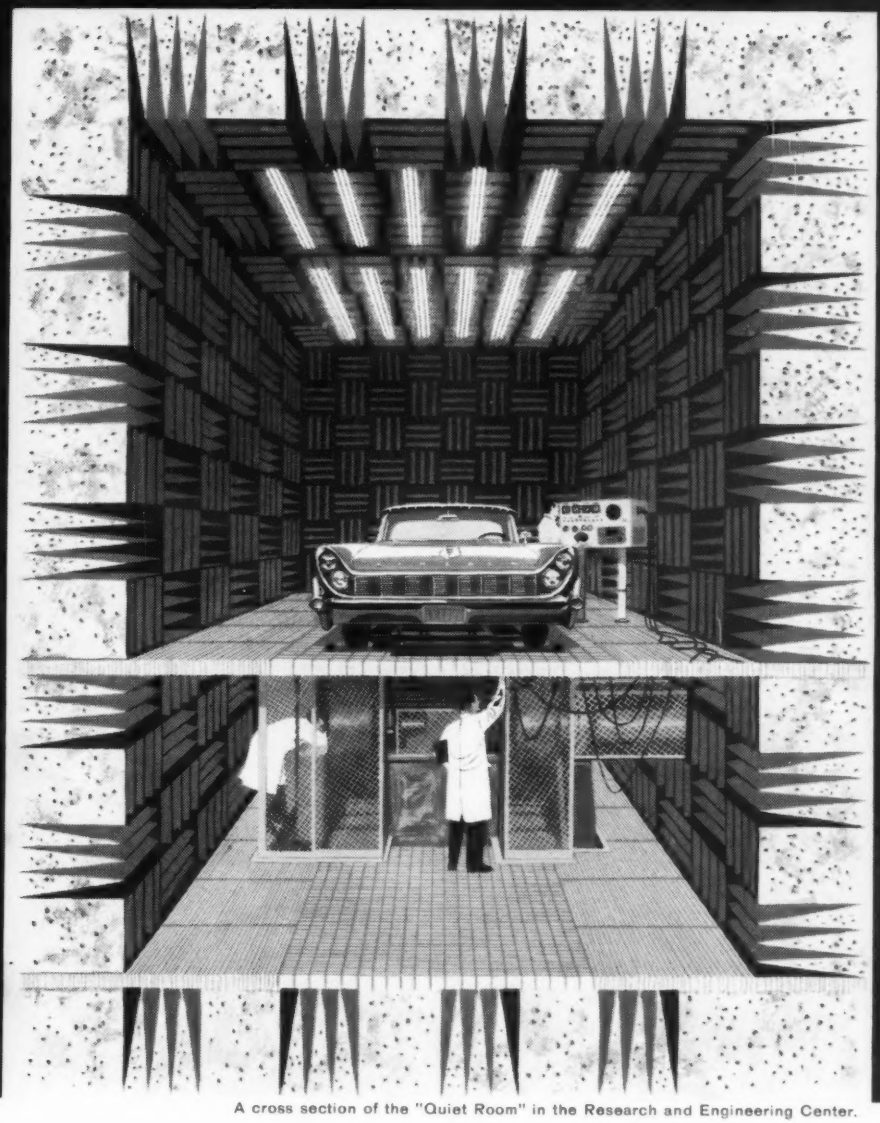
Lockheed, whose Electra prop-jets are destined to gain a major share of the nation's short-and-medium range airline markets, invested $5,850,000 to flight-test its first prototype. A 1/16th scale model of the Electra was flown more than 60,000 simulated miles in wind tunnels at top speed. Full-scale models of the 400-mile-an-hour transport were subjected to ultrasonic testing and gone over with X rays and fluoroscopes to detect minute flaws.

The Electra's husky Allison jets were run at full throttle on test stands while scoops of dust were thrown right into the jet air intakes. They kept on working. After six hours — when 253 pounds of dust had been thrown into the jets — they were still running smoothly, without measurable damage to any key parts.

Convair's 880 is the fastest of the new pure-jets (estimated cruising speed: 630 mph), though it will be the last to get into service. It has extra-thick fuselage skins. These reduce skin stress to such a low level that fatigue cracks will never develop. The thick skin also cuts down on vibration and interior noise. For one test, Convair developed its own gunlike machine. It fired hailstones, up to the size of a golf ball, against the wing and tail leading edges at speeds up to 575 miles an hour. The skin survived the test unpunctured. The 880's wings are a brand new three-spar design: chance failure cannot affect the structural integrity of the wing. The 880's GE CJ-805-3 turbojets were test-flown across the country and back, mounted in an Air Force RB-66-A bomber. The flight set a new three-hour, 36-minute speed record on the Los Angeles-Washington run, while proving the engine's reliability. They were also tested atop Mount Washington in New Hampshire, where they were subjected to sub-zero cold and to winds up to 175 miles an hour.

Roaring across the world's air oceans at 35,000 feet, America's jet-transport pilots are inaugurating a new era in super-fast, super-safe aviation, thanks to the fabulous research and testing methods. As they pass the Comet 4's, competing with them now in a brilliant comeback, they wave a silent salute: an airman's tribute to the invaluable lessons learned from the Comet disasters.

THE SCIENCE OF CARS



A cross section of the "Quiet Room" in the Research and Engineering Center.

The "Quiet Room" . . . *it's where we eliminate the shake, rattle and roll from the Ford Family of Fine Cars*

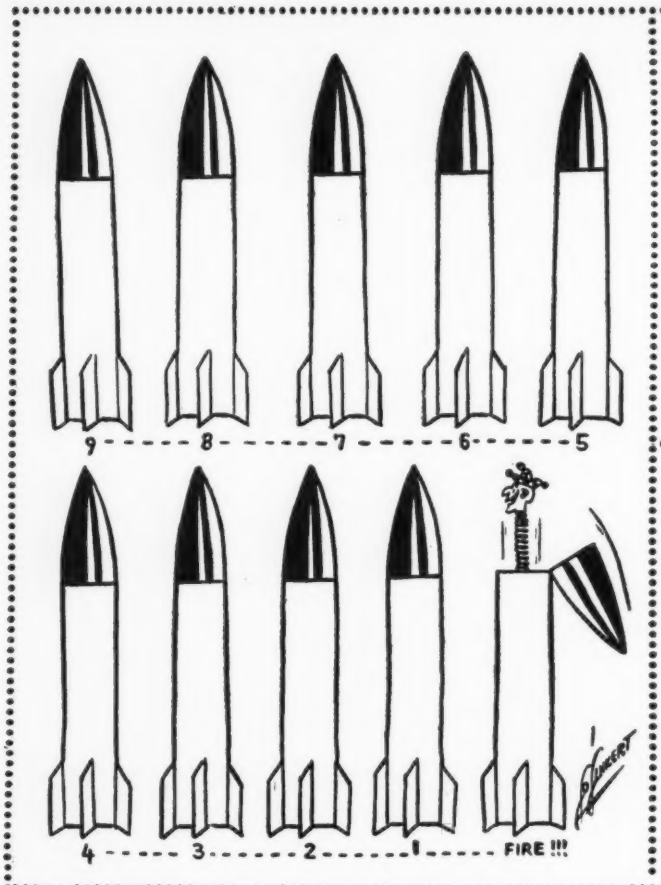
Outside walls are a foot thick. Inside walls are made of four-foot wedges of glass fiber. The result is what we call an "anechoic" room — a room without echoes. It's the only one of its kind in the entire automobile industry.

Working in this unique sound lab, Ford Motor Company engineers simulate every conceivable road condition from cobblestones to railroad ties. In this way, sounds from the tires, engine, transmission or any other part of the car can be isolated, analyzed, and what's most important, minimized or eliminated.

The "Quiet Room" is just one example of the extra investment in money and minds we make in order to build better quality into the Ford Family of Fine Cars.

FORD MOTOR COMPANY
THE AMERICAN ROAD, DEARBORN, MICHIGAN

FORD • THUNDERBIRD • EDSEL • MERCURY • LINCOLN • CONTINENTAL MARK IV



Yours for the asking

PLEASE NOTE: "Yours for the Asking" coupons from 1958-59 issues will NOT be valid after June 1.

Bausch & Lomb Optical Company offers a notebook chart that illustrates working parts of a standard-model microscope. The reverse side contains a glossary of 38 mechanical and optical terms. Check No. 551.

Three pamphlets by the New York Life Insurance Company give advice on varied careers. *Should You Be a Newspaperman?* by George C. Biggers, president of Atlanta Newspapers, Inc., dispels several false notions about reporting and gives facts about college preparation, opportunities for women, the value of "basic training" in news reporting for careers in allied fields. The former dean of Harvard Law School, Roscoe Pound, reviews the advantages and potentialities of a legal career in *Should You Be a Lawyer?* If you are "reality-minded," imaginative, unusually inquisitive, you may be suited for a career in aeronautical engineering. Igor Sikorsky discusses this field in *Should You Be an Aeronautical Engineer?* Check Nos. 552, 553, and 554, respectively.

The National Agricultural Chemicals Association has prepared a 64-page illustrated booklet, *Open Door to Plenty*, to give a thorough picture of the role played by agricultural chemicals in the protection of our food, property, and health. The material covers a span of time — from early efforts to conquer pest-caused disease and famine to current legislation designed to protect consumers against present-day chemicals. Special features: chronological chart of landmarks in pest control; three-pronged chart (showing biology, chemistry, toxicology) that defines stages in development of a new pesticide; glossary. Check No. 555.

Check your choice, clip coupon, and mail to: **Yours for the Asking, Science World, Room 410, 10 East 43 Street, New York 17, N. Y.**

- ☐ 551 Microscope Chart
- ☐ 552 Should You Be a Newspaperman?
- ☐ 553 Should You Be a Lawyer?
- ☐ 554 Should You Be an Aeronautical Engineer?
- ☐ 555 Open Door to Plenty

See also: p. 31

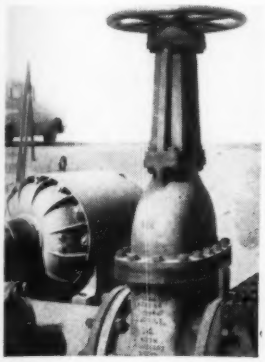
NAME _____

ADDRESS _____

CITY _____ ZONE _____ STATE _____

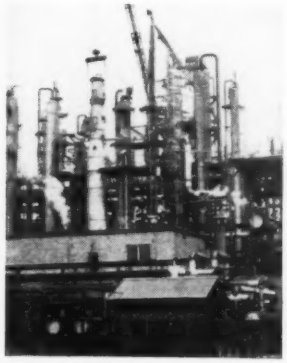
PLEASE PRINT

Metal quiz... you might have to take one like it again when you design equipment. Try your hand at it now. But remember to take advantage of the help INCO can give you when really tough metal quizzes come your way in your future engineering jobs.



☐ **Refinery valve**—Needed: resistance to attack from petroleum products, thermal and hydraulic shock. Which alloy . . . ?

☐ **Turbojet afterburner shell**—Needed: strength plus corrosion resistance at high temperatures. Which alloy . . . ?

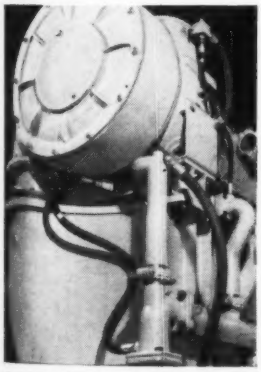


☐ **Recovery tower**—Needed: resistance to hot coke oven gases and aromatic chemicals, long service life. Which alloy . . . ?

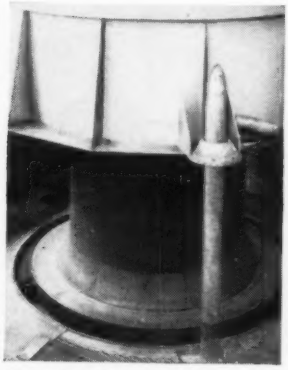
See if you can tell which of these nickel-containing alloys proved to be the answer to these problems. Put the right number in the right box.

1. Ductile Ni-Resist*
2. Nimonic "75"* nickel-chromium alloy
3. Nickel-aluminum bronze
4. Ductile iron
5. Monel* nickel-copper alloy
6. Inconel* nickel-chromium alloy
7. Type 316 chromium-nickel stainless steel

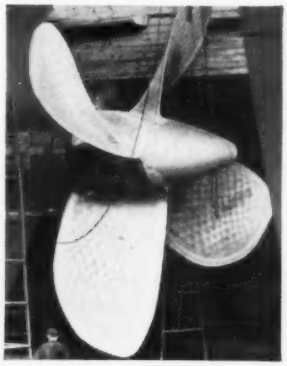
See answers below



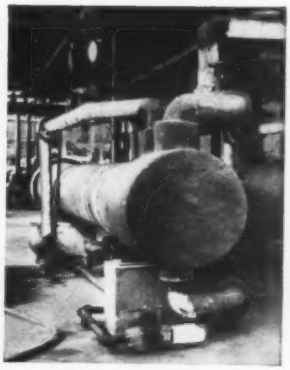
☐ **Diesel manifold**—Needed: scaling and oxidation resistance at 1200°F, resistance to thermal shock. Which alloy ?



☐ **Heat treating retort**—Needed: light weight, ability to endure destructive heating-cooling cycles. Which alloy . . . ?



☐ **Ship's propeller**—Needed: lighter weight and resistance to erosion and salt water corrosion. Which alloy . . . ?



☐ **Regenerator pre-heater**—Needed: trouble-free service handling hot caustics, fabricating ease. Which alloy . . . ?

When you start to design equipment, you'll have to select the proper material to meet given service conditions . . . a material that might have to resist corrosion, or wear, or high temperatures, or a combination of these conditions.

Over the years, Inco Development and Research has gathered information on the performance of materials in many such problems. Inco's List "A" and List "B" contain descriptions of 377 Inco publications which are available to you, covering applications and properties of Nickel and its alloys. For Lists "A" and "B", write Education Services.

The International Nickel Company, Inc., New York 5, N. Y.

*Registered trademark

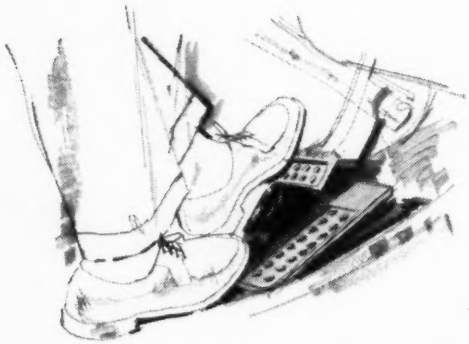
ANSWERS:
- Refinery valve . . . Ductile iron
- Turbojet afterburner shell . . . Nimonic "75"
- Recovery tower . . . Type 316 stainless
- Diesel manifold . . . Ductile Ni-Resist
- Heat treating retort . . . Inconel alloy
- Ship's propeller . . . Nickel-aluminum bronze
- Regenerator pre-heater . . . Monel alloy

Inco Nickel

makes metals perform better, longer

4 FACTS ABOUT CARS WE'LL BET YOU DON'T KNOW

(Or—maybe you do! Why not check down the list and find out?)

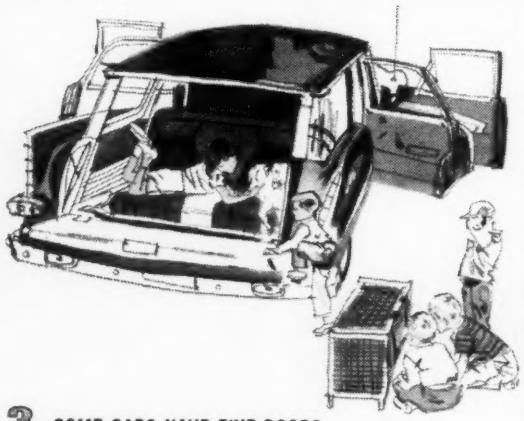


1. YOU CAN BRAKE FASTER WITH YOUR LEFT FOOT

Actually, 0.3 second faster. At 30 mph, that's 13 feet! Left-foot braking is easy in Chrysler Corporation cars with automatic transmission, because of the extra-wide brake pedal. And big Total-Contact Brakes, insure safe, even stopping at the touch of a toe.

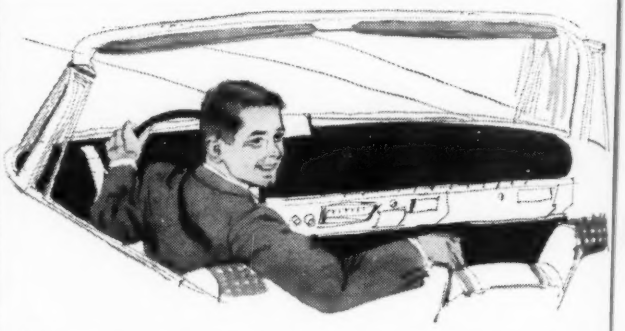
2. YOU SHOULD STEP ON THE GAS IN A CURVE

For most control, slow down *before* the curve, then feed gas gradually. Sure control comes easy in Cars of The *Forward* Look. Experts says Torsion-Aire Suspension makes them the best-handling, smoothest-riding cars in America.



3. SOME CARS HAVE FIVE DOORS

The "Fifth Door", introduced by Chrysler Corporation 9-passenger Station Wagons, lets you get into the rear seat without climbing over the seat in front of it. The secret? Rear seat faces back—rear window rolls down—tailgate becomes another door.



4. IT'S SAFER TO BACK UP WITH ONLY ONE HAND ON THE WHEEL

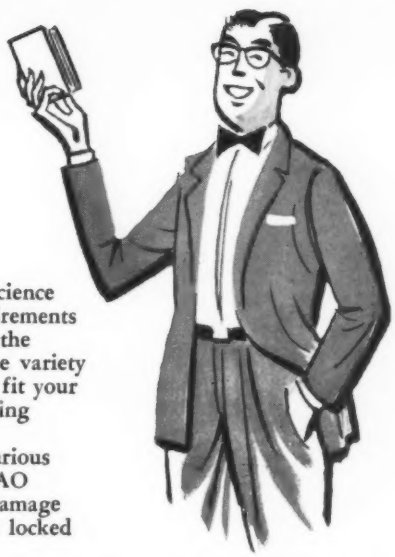
This technique gives you better visibility, makes parking easier. Deft parking's a snap with Chrysler Corporation's Constant-Control Power Steering. It works full-time, helps you steer and park like an expert.

And—do you know this? There are big differences among new cars today. Find out for yourself. Ask Dad to visit the dealer's with you—so both of you can take a drive in the cars that give you most for 1959: The Cars of The *Forward* Look!

CHRYSLER CORPORATION

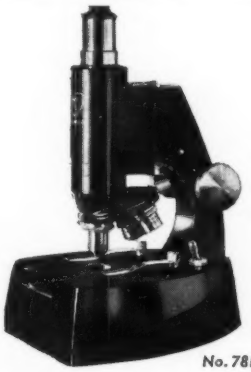
PLYMOUTH · DODGE · DESOTO · CHRYSLER · IMPERIAL

THERE'S AN AO SPENCER STUDENT MICROSCOPE TO SUIT YOUR EXACT TEACHING PLAN



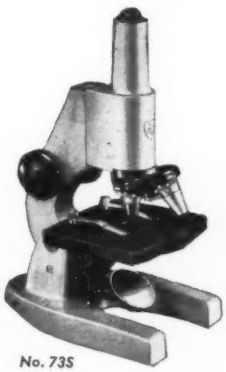
What is the best teaching microscope? Thousands of Science Teachers have told us there is no single answer. Requirements differ with budget restrictions, the age of students and the course being taught. That's why AO Spencer makes the variety of models shown here. You'll find that one will exactly fit your specific needs, that all are designed to make your teaching hours more productive.

Realizing that students are at all times wonderfully curious and sometimes impetuous, focusing adjustments on all AO teaching microscopes are "spring loaded" to prevent damage to objectives and costly slides. Eyepieces and objectives locked in, if desired.



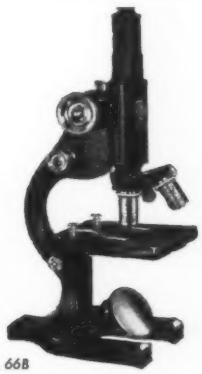
No. 78BA

78 A low-cost teaching microscope that requires little or no instruction into the technique of microscopy. Your time is spent solely on subject matter. Built-in base illuminator assures proper illumination. Helps students observe specimens properly.



No. 73S

73 A quality instrument with a low price tag! Designed for the class where acquisition of subject matter is the primary teaching objective. Low overall height and single precise focusing adjustments make the No. 73 easy to use. Attached substage illuminator available.



No. 66B

66 One of the most popular Teaching Microscopes in America! Traditional design and minimum maintainance make it ideal for the class where acquisition of subject matter *and* skill in microscopy are *both* important considerations. All metal, standard size instrument with top quality optics. Coarse and fine adjustments. Attached substage illuminator available.

American Optical Company

INSTRUMENT DIVISION, BUFFALO 15, NEW YORK

Gentlemen: Dept. Q-252

Please send me complete information on AO Spencer Student Microscopes, No. 66 ☐, No. 73 ☐, No. 78 ☐.

Name.....

Address.....

City.....Zone.....State.....

Shop talk

Reinhart Schwemmer, who teaches physics, chemistry, and geometry at Beloit (Kansas) High School, writes:

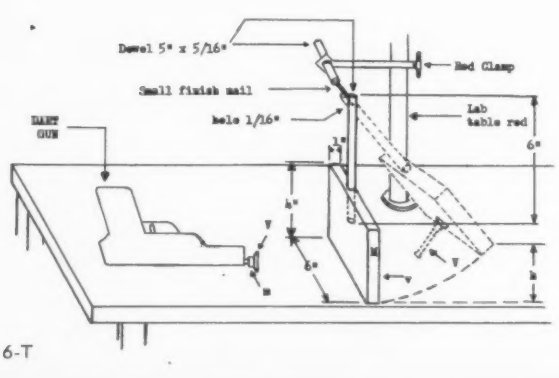
Here is a ballistics demonstration experiment that is very easily performed and that proves interesting to physics students. You can use it to compute the velocity of a vacuum-cup dart shot from a toy dart gun. The dart and gun can be purchased from most five-and-ten-cent stores for about fifty cents.

First, a ballistics pendulum must be made. The industrial arts teacher made one for me (see drawing) in about ten minutes. You can make it as follows:

Cut a rectangular block from a piece of 1-inch pine to measure 4 inches wide and 6 inches long. Drill a hole 5/16 inch in diameter into the center of the 6-inch edge to a depth of 1 inch. A dowel pin 5/16 inch in diameter and 6 inches in length is driven into the hole in the block. A hole 1/16 inch in diameter is then drilled through the dowel parallel to the block and ½ inch from the top. This completes the ballistic pendulum block.

To provide a support for the pendulum block, take a dowel 5/16 inch in diameter and cut it to a length of 5 inches. Drive a small finishing nail (one that will easily go through the 1/16-inch hole in the first dowel) into the center of one of the flat sides of the 5-inch dowel. The nail should extend about ¾ of an inch out of the dowel. Now place the 5-inch dowel horizontally in a lab-table rod clamp. Hang the pendulum block from this support by inserting the finishing nail in the 1/16-inch hole in the pendulum dowel. Regulate the height of the rod clamp so that the pendulum block almost touches the top of the lab table, yet swings freely.

You are now ready to collect your data for the experiment. Weigh and record the weight of the vaccuum-cup dart (bullet). Remove the pendulum block from the nail support and weigh and record its weight. Then replace it. Fire the dart at a point near the lower center of the pendulum block. If the dart does not stick, you will need to tape a piece of smooth metal or plastic to the front of the pendulum block and re-weigh it. Have someone observe and mark the distance the pendulum block swings when hit by the dart. Now bring the pendulum block back to the observed distance and measure its vertical height above the table top. A small, light piece of cardboard bent at a right angle and placed back of the pendulum block may be used to mark the distance the pendulum is forced back by the dart. The pendulum block can then be moved back to that distance and the height measured.



In computing the velocity of a bullet, we make use of the laws of conservation of momentum. The momentum before collision is equal to the momentum after impact. The ballistics pendulum of mass (M) is suspended from a rod so as to swing freely. When a dart of mass (m) is shot horizontally onto the pendulum block, it sticks there and imparts a certain velocity (v) to the total mass ($M + m$). The pendulum is pushed back, and the vertical height (h) through which it rises is measured. From this height the initial velocity (v) of the pendulum can be computed from the equation $v = \sqrt{2gh}$ (g represents acceleration due to gravity). Then, as a result of the conservation of momentum, the velocity of the dart can be computed from the equation $V = (m + M)\, v/m$.

(V) velocity of the dart
(v) velocity of the pendulum block
(m) mass of the dart
(M) mass of the pendulum block
(h) vertical height that pendulum block swings

Here are the data and solution from the experiment we performed:

$v = 94$ cm./sec. ($v = \sqrt{2gh}$; $v = \sqrt{2\,(980 \text{ cm.})\ (4.5 \text{ cm.})}$; $v = 94$ cm./sec.)
$h = 4.5$ cm.
$m = 6$ gm.
$M = 125$ gm.

$$V = \frac{(m + M)v}{m}$$

$$V = \frac{(6 \text{ gm.} + 125 \text{ gm.})\ 94}{6 \text{ gm.}}$$

$$V = 2052 \text{ cm./sec.}$$

Converting this speed to ft./sec., we have

$$2.54 \text{ cm.} = 1 \text{ in.}$$
$$2.54 \times 12 \text{ in.} = 30.5 \text{ cm./ft.}$$
$$\frac{2052 \text{ cm.}}{30.5 \text{ cm.}} = 67 \text{ ft./sec.}$$

Converting to miles per hour, we have

$$88 \text{ ft./sec.} = 60 \text{ mph; so}$$
$$\frac{88 \text{ ft.}}{60 \text{ mph}} = \frac{67 \text{ ft.}}{(x)\text{mph}}$$
$$x = 46 \text{ mph}$$
$$\text{Velocity of dart} = 46 \text{ mph}$$

Twenty-five dollars will be paid for material used in "Shop Talk." The editors regret that they cannot return unused contributions. Send to: Science World Shop Talk, 575 Madison Avenue, New York 22, N. Y.

Check your choices, clip this coupon, and mail to
Science Teacher's World, Dept. TT
575 Madison Ave., New York 22, N. Y.

☐ 55A ☐ 55B ☐ 55C ☐ 55D

See also: p. 5-T; p. 8-T

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PLEASE PRINT

TEACHER'S TOOLS

CENCO, one of the leading manufacturers of laboratory apparatus for schools, offers several free teaching aids for secondary school science instructors. They include lists of apparatus and supplies needed for demonstrations and experiments in science courses. Write for them, using the following pamphlet numbers: GS6, General Science; B8R2, Biology; HSC-7, Chemistry; P-12, Physics; DMW, Physics Workbook Experiments; and DMB, Demonstration of Physical Laws. Elementary school science administrators and teachers will be especially interested in Cenco's new 24-page bulletin ES-4, which lists and describes suggested equipment from kindergarten through the eighth grade. Send your requests to Central Scientific Company, 1700 Irving Park Road, Chicago 13, Ill. (*Do not use coupon for this material.*)

The HAYS CORPORATION offers science instructors a varied number of scientific instruments for use in advanced chemistry and physics courses and in specialized teaching situations. As an example, the Hays Orsat Gas Analyzer provides for a significant demonstration of measuring gases. It is a compact, rugged, accurate, portable, fast analyzer that is extremely easy to use. It is used by thousands of firemen, combustion engineers, chemists, and laboratory technicians. (*For details, check No. 55A.*)

FISHER SCIENTIFIC COMPANY's Vibro-Spatula "rings the bell" for something both unique and highly useful in the laboratory. One of several spatulas in the Fisher line, made of materials ranging from stainless steel to porcelain and glass, the Vibro-Spatula features the happy "marriage" of an electric vibrator to a 4½-inch corrosion-resistant stainless steel spatula. The vibrator is small and designed to fit the operator's hand comfortably. "Dead-stop end point" can be applied to weighings when the Vibro-Spatula controls the dispensing of the sample to the pan of an analytical balance. (*For information on this and other Fisher spatulas, check No. 55B.*)

THERMO ELECTRIC MANUFACTURING COMPANY produces a complete line of hot plates, flask heaters, electric furnaces, magnetic stirrers, and temperature controlling and indicating instruments for the science classroom and laboratory. One of Tempco's featured product lines includes its well-known hot plates. All of these specialized units offer lots of heating space with plenty of reserve power for any laboratory need. One and three-quarters inches of insulation protects the control section and table top from heat damage. The hot plates offer variable control from 140° F. to 800° F., with automatic adjustment for variations in supplied voltage and room temperatures. 115 or 230 volts. (*To receive full details on these hot plates and laboratory units, check No. 55C.*)

Some rules for safe driving are given in the GENERAL MOTORS advertisement on page 2 in this issue of the student magazine, titled "The Rest Is Up to You." (*If you would like a reprint to post on your bulletin board, check No. 55D.*)

HE KNOWS FREEDOM IS NOT FREE!

Do You?

● Bela Varga knows the price of freedom. He escaped from behind the Iron Curtain, leaving home, family, belongings behind. But millions like him remain in the oppressed countries of East Europe. Your dollars are needed to keep their spirit of freedom alive by keeping Radio Free Europe on the air. You see, Radio Free Europe is a private organization . . . supported by the American people. Your truth dollars pay for transmitters, equipment, announcers, news analysts. Send them in today!

SEND YOUR TRUTH DOLLARS TO
CRUSADE *for* FREEDOM
CARE OF YOUR LOCAL POSTMASTER

INCO suggests

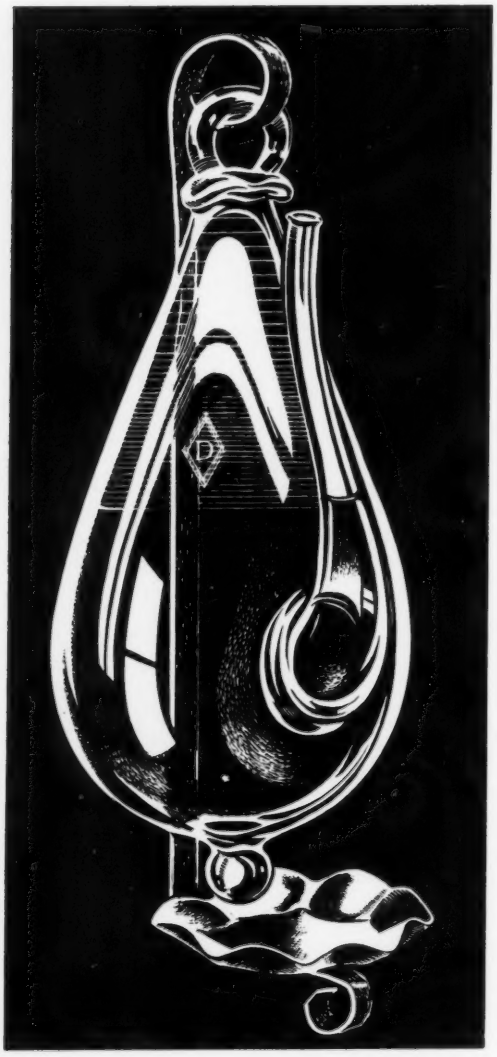
The following student activities are based on the INCO advertisement, p. 31.

For discussion: (1) What are some modern nickel-containing alloys? (2) How do they vary in their properties?

For demonstration: (1) Obtain a nickel-steel aircraft bolt and an ordinary steel bolt (both the same size: ¼" in diameter or less). Place them in a vise, and observe that the nickel-steel bolt does not give as readily as the ordinary steel bolt. As a safety measure, be sure to cover the top of the vise to prevent injury as the steel bolt disintegrates. (2) Place a piece of nickel-containing alloy and a piece of ordinary iron in ocean-water samples or in a 3 per cent salt solution. Compare the corrosion rates.

Special Offer!

FOR SCIENCE TEACHERS ONLY



THE OL' NANTUCKET WEATHER GLASS

The Ol' Nantucket Weather Glass truly captures the flair and flavor of the square-rigged sailing ships that moved gracefully off Nantucket Light more than a century ago. A beautifully hand-blown antique, this seafaring reproduction is an entirely-practical weather barometer, ideally suited for use in the classroom or even in the home.

The crystal-clear, pear-shaped pendant, hand blown by Doerr craftsmen, is gracefully suspended from a wrought-iron bracket and fascinates both teacher and student alike. A splendid teaching aid in explaining barometric pressures, it is, at the same time, an attractive wall ornament.

To obtain your Ol' Nantucket Weather Glass, see details included in the special offer below. Address your letters to: Doerr Glass Company, 1020 Peach Street, Vineland, New Jersey.

OL' NANTUCKET WEATHER GLASS SPECIAL

In better gift or specialty shops, this item, which measures 10¼ inches in overall length, sells for $4.25 and up. To introduce science teachers to Diamond D glassware quality, we are offering our trademarked Ol' Nantucket Weather Glass for $1.00 which represents practically the cost of handling alone. Obviously, this offer is limited . . . so HURRY! Send a note on your school stationery and include your $1.00 in cash, check or money order. You will receive by return mail your beautiful Ol' Nantucket Weather Glass. We will also include instructions for filling and coloring the water and reading the glass to determine weather conditions. Don't wait! Send a note on your school stationery with $1.00 to Doerr Glass Company and receive your beautiful Ol' Nantucket Weather Glass by return mail. Our supply is limited so you must act fast!

Yours For Only $1.00

Doerr Glass Company, Vineland, New Jersey.
Please send me an Ol' Nantucket Weather Glass for which I have enclosed my $1.00.

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